PRICE $2.00

03809

HEATHKIT®
ASSEMBLY MANUAL

HEATH COMPANY • BENTON HARBOR, MICHIGAN

VOLT-OHM-MILLIAMMETER
MODEL IM-105

595-1335

TYPICAL COMPONENT TYPES

This chart is a guide to commonly used types of electronic components. The symbols and related illustrations should prove helpful in identifying most parts and reading the schematic diagrams.

Assembly and Operation of the HEATHKIT

VOLT-OHM-MILLIAMMETER

MODEL IM-105

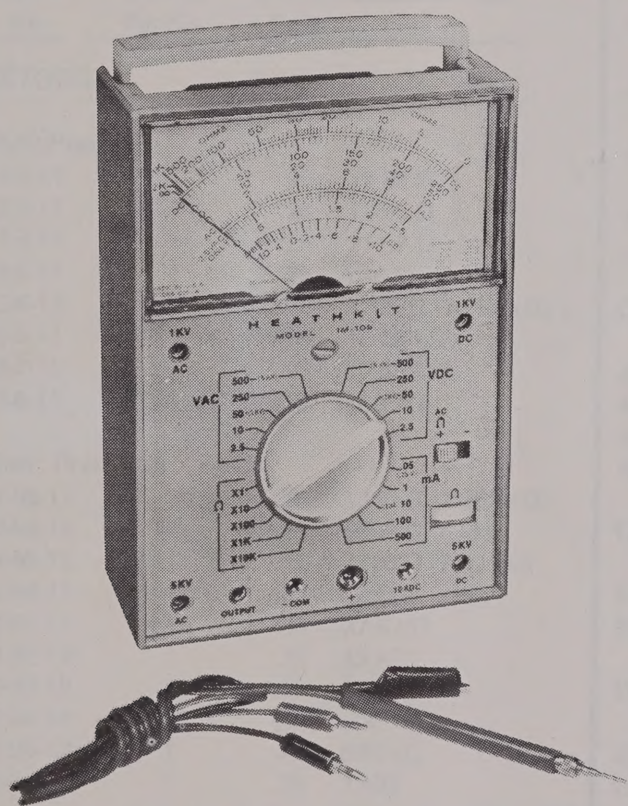


TABLE OF CONTENTS

HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

INTRODUCTION

The Heathkit Model IM-105 is a highly accurate and dependable multimeter which has a wide range of applications. Entirely self-contained, this Instrument is always ready for field or laboratory use. The straight-forward design and circuit board-connecting system provide a most easy-to-assemble instrument that is every bit as rugged as it is accurate.

The Model IM-105 has a basic accuracy of ±3% on the dc ranges and ±4% on the ac ranges. Sensitivity is 20,000 ohms per volt on the dc ranges and 5000 ohms per volt on the ac ranges.

The ruggedized, taut-band Weston meter movement is protected with a diode overload circuit, while the main input connector is in-line fused. Effects of temperature changes are reduced to a minimum by the use of thermistor compensation and low-drift metal film resistors on most input ranges.

Another important feature is the high impact-strength Lexan case. This case, while small enough to be easily stored in a briefcase or tube caddie, contains full-size, easy-to-read scales.

This Meter is sure to provide you with a versatile, accurate, and attractive test instrument that is designed for long and dependable service.

Refer to the "Kit Builders Guide" for additional information on unpacking, parts identification, tools, wiring, soldering, and step-by-step assembly procedures.

PARTS LIST

Check each part against the following list. The key numbers correspond to the numbers in the Parts Pictorial (fold-out from Page 5).

To order replacement parts, refer to the Price Each column and use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to "Replacement Parts" in the "Kit Builders Guide."

The following prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Add 10% (minimum 25 cents) to the price when ordering from a Heathkit Electronic Center to cover local sales tax, postage and handling. Outside the U.S.A. parts and service are available from your local Heathkit source and will reflect additional transportation, taxes, duties and rates of exchange.

KEY No.	PART No.	PARTS Per Kit.	PRICE Each	DESCRIPTION
RESISTORS				
1/8-Watt,Precision				
A1	2-1-11	1	.25	23.68 Ω
A1	2-2-11	1	.25	175.5 Ω
A1	2-3-11	1	.25	211.7 Ω
A1	2-4-11	1	.25	236.8 Ω
A1	2-5-11	1	.25	1755 Ω (1.755 kΩ)
A1	2-6-11	1	.25	16.68 kΩ
A1	2-7-11	1	.25	17.55 kΩ
A1	2-8-11	1	.25	180 kΩ
1/4-Watt, Precision				
A2	2-98-12	2	.25	1350 Ω (1.350 kΩ)
A2	2-88-12	2	.25	5000 Ω (5 kΩ)
A2	2-89-12	1	.25	7320 Ω (7.32 kΩ)
A2	2-68-12	1	.25	20 kΩ
A2	2-91-12	1	.25	37.5 kΩ
A2	2-92-12	1	.25	45 kΩ
A2	2-93-12	1	.25	150 kΩ
A2	2-94-12	1	.25	200 kΩ
A2	2-95-12	1	.25	800 kΩ
A2	2-96-12	1	.25	1 MΩ
1/2-Watt, Precision				
A3	2-298	1	.45	19.5 Ω
A3	2-299	1	.35	1.25 MΩ
A3	2-300	1	.35	2.5 MΩ
A3	2-301	1	.60	4 MΩ
A3	2-302	1	.60	5 MΩ
A3	2-303	1	1.10	10 MΩ
Other Resistors				
A4	2-24-2	1	.75	20 MΩ, 2-watt precision
A4	2-25-2	1	2.85	80 MΩ, 2-watt, precision
A5	3-1-3	1	.75	.4997 Ω, 3-watt, wire-wound
A5	3-2-3	1	.65	2.106 Ω, 3-watt, wire-wound
A5	3-3-3	1	.65	6.617 Ω, 3-watt, wire-wound
A6	1-152	1	.10	11 kΩ, 1/2-watt (brown-brown-orange)
A7	100-1054	1	1.95	.0263 Ω shunt resistor assembly
A8	9-44	1	1.50	1500 Ω thermistor
CONTROLS				
A9	10-367	1	.40	1000 Ω, (1 k0) control
A9	10-368	1	.40	2200 Ω, (2 k2) control
A9	10-369	1	.40	4700 Ω, (4 k7) control
A10	10-363	1	.55	100 kΩ control
CAPACITORS				
B1	21-82	1	.10	.02 μF disc
B2	27-130	1	.45	.22 μF Mylar*
DIODES				
C1	56-56	2	.20	1N4149
C2	56-89	2	.20	GD510

*DuPont Registered Trademark

KEY No	PART No	PARTS Per Kit	PRICE Each	DESCRIPTION
SWITCHES				
D1	60-61	1	.40	Slide switch
D2	63-616	1	1.65	Front wafer switch (with blue color dot)
D2	63-617	1	1.20	Rear wafer switch (with black color dot)
CONNECTORS-SOCKETS-PLUGS				
E1	432-123	7	.10	Molex* connector
E2	432-188	1	.20	Fuseholder
D3	432-189	7	.10	Pin connector
E4	436-36	4	.35	Long banana socket
E5	436-37	1	.20	Short banana socket
E6	436-38	2	.65	Threaded banana socket
E7	436-39	1	.70	Banana socket/ fuseholder
E8	438-13	2	.15	Banana plug
E9	439-1	1	.45	Red test probe
E10	260-1	1	.10	Alligator clip
HARDWARE				
F1	250-545	3	.05	4-40 x 5/16" screw
F2	250-546	2	.20	4-40 x 1-1/4" hexagon head screw
F3	258-143	1	.05	Coil spring
F4	260-67	4	.05	Battery clip
WIRE-LEADS				
	341-1	1	.10/ft	Black test lead
	341-2	1	.10/ft	Red test lead
	344-50	1	.05/ft	Black hookup wire
	344-52	1	.05/ft	Red hookup wire
	344-55	1	.05/ft	Green hookup wire
	344-59	1	.05/ft	White hookup wire
MISCELLANEOUS				
G1	70-5	1	.10	Black banana plug holder
G1	70-6	1	.10	Red banana plug holder
G2	73-21	1	.10	Alligator clip cover

*Registered Trademark, Molex Products Co.

KEY No.	PART No.	PARTS Per Kit	PRICE Each	DESCRIPTION
Miscellaneous (cont'd.)				
G3	73-47	1	.10	Large battery cushion
G4	263-7	1	.05	Small battery cushion
G5	75-157	1	.10	Dust cover
G6	421-45	1	.15	2-ampere fuse
	85-526-1	1	1.15	Front circuit board
	85-527-1	1	1.15	Rear circuit board
	390-393	1	.25	Calibration label
	391-34	1		Heath identification label
	597-308	1		Kit Builders Guide
	597-260	1		Parts Order Form
	100-1049	1	29.95	Complete meter and case assembly
				Solder (Additional 3' rolls of solder, #331-6, can be ordered for 15 cents each.)
			2.00	Manual (See front cover for part number.)

NOTE: In addition to the complete meter and case assembly listed above, two parts packages and several individual parts for the meter case are available for replacement purposes. These parts are listed on Page 48.

BATTERIES

The following batteries should be purchased at this time for use in your kit:

1 1.5-volt, D-cell, zinc-carbon battery (NEDA 14).
1* 15-volt, zinc-carbon battery (NEDA 208).

*Representative manufacturers and their type numbers are:

Burgess	U10
Eveready	411
Mallory	M208
Ray-O-Vac	208
RCA	VS083

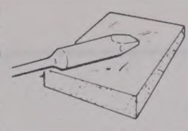
CAUTION: Do not use alkaline batteries in this meter.

STEP-BY-STEP ASSEMBLY

CIRCUIT BOARDS

FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN...

WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.



START

( ) Position the rear circuit board (#85-527) as shown in Pictorial 1-1. Then complete each step on Pictorial 1-1.

( ) 2.5 MΩ resistor.

( ) 1.25 MΩ resistor.

( ) 1 MΩ resistor.

( ) 200 kΩ resistor.

( ) 37.5 kΩ resistor.

( ) 7320 Ω (7.32 kΩ) resistor.

( ) 20 kΩ resistor.

( ) 5000 Ω (5 kΩ) resistor.

( ) 20 MΩ resistor.

( ) Solder all leads to the foil and cut off the excess lead lengths.

( ) 175.5 Ω resistor.

( ) 5000 Ω (5 kΩ) resistor.

( ) 17.55 kΩ resistor.

( ) 1755 Ω (1.755 kΩ) resistor.

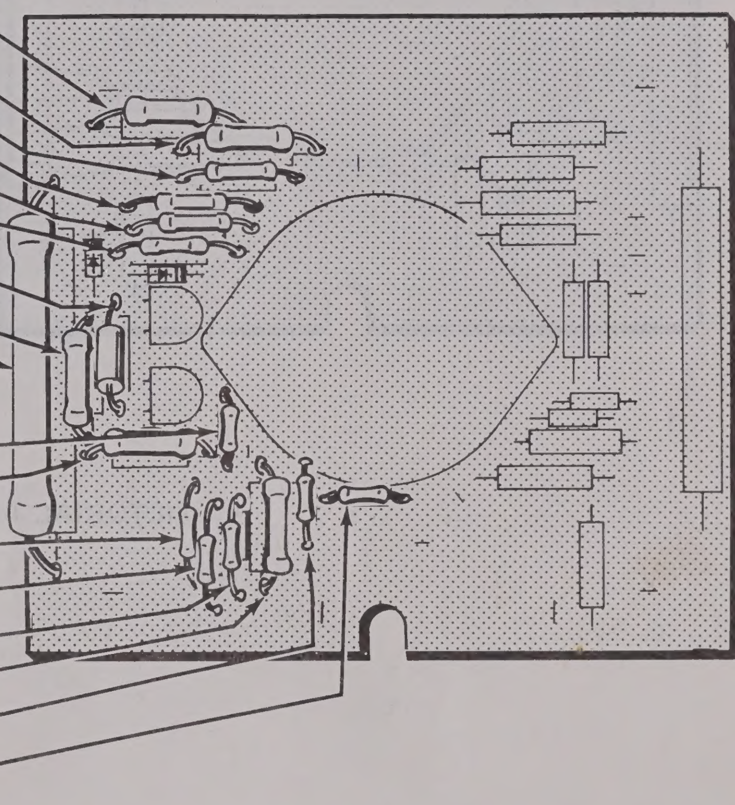
( ) 16.68 kΩ resistor.

( ) 6.617 Ω resistor.

( ) 211.7 Ω resistor.

( ) 180 kΩ resistor.

( ) Solder all leads to the foil and cut off the excess lead lengths.



PICTORIAL 1-1

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SWITCHES				
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RCA	VS083

CAUTION: Do not use alkaline batteries in this meter.

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STEP-BY-STEP ASSEMBLY

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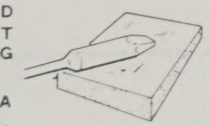
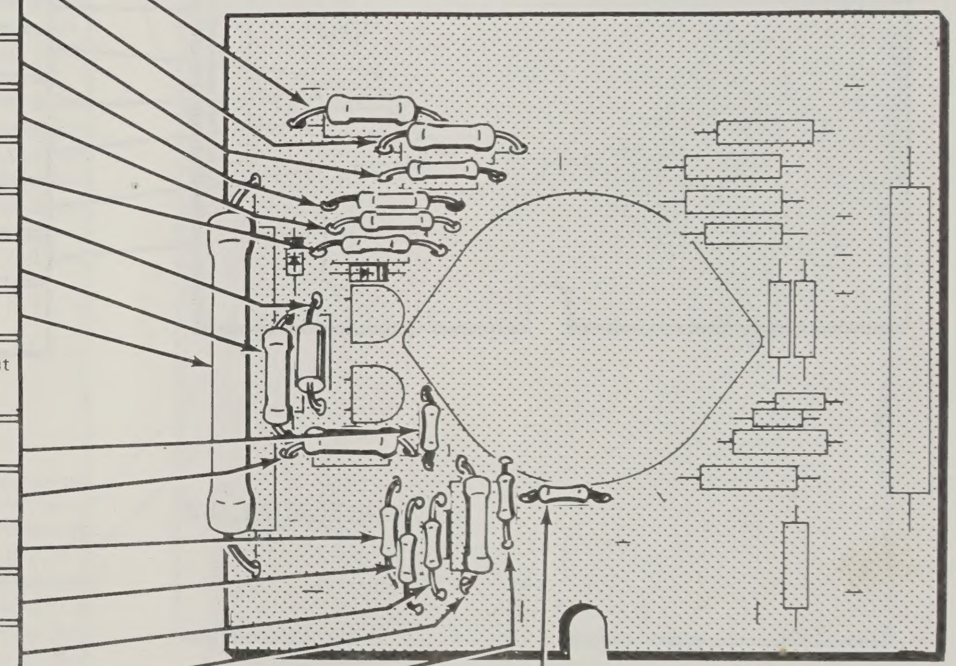


START

( ) Position the rear circuit board (#85-527) as shown in Pictorial 1-1. Then complete each step on Pictorial 1-1.

( ) 2.5 MΩ resistor.
( ) 1.25 MΩ resistor.
( ) 1 MΩ resistor.
( ) 200 kΩ resistor.
( ) 37.5 kΩ resistor.
( ) 7320 Ω (7.32 kΩ) resistor.
( ) 20 kΩ resistor.
( ) 5000 Ω (5 kΩ) resistor.
( ) 20 MΩ resistor.
( ) Solder all leads to the foil and cut off the excess lead lengths.
( ) 175.5 Ω resistor.
( ) 5000 Ω (5 kΩ) resistor.
( ) 17.55 kΩ resistor.
( ) 1755 Ω (1.755 kΩ) resistor.
( ) 16.68 kΩ resistor.
( ) 6.617 Ω resistor.
( ) 211.7 Ω resistor.
( ) 180 kΩ resistor.
( ) Solder all leads to the foil and cut off the excess lead lengths.



PICTORIAL 1-1

MBLY

SOLDERED
YOU MUST
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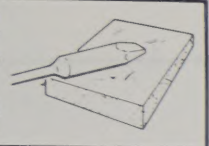
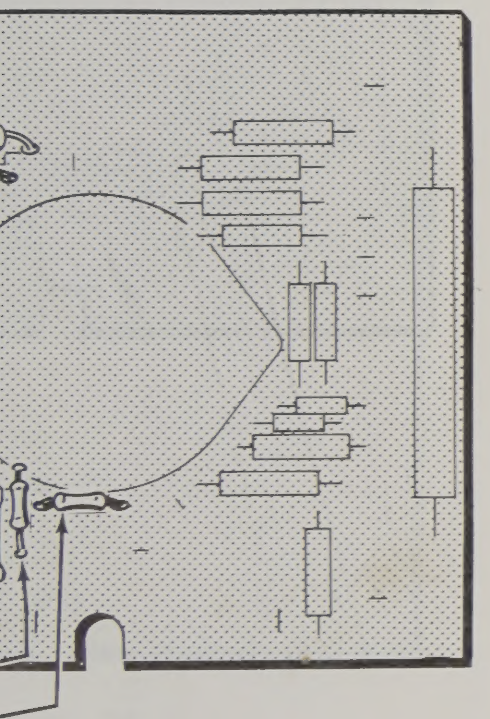
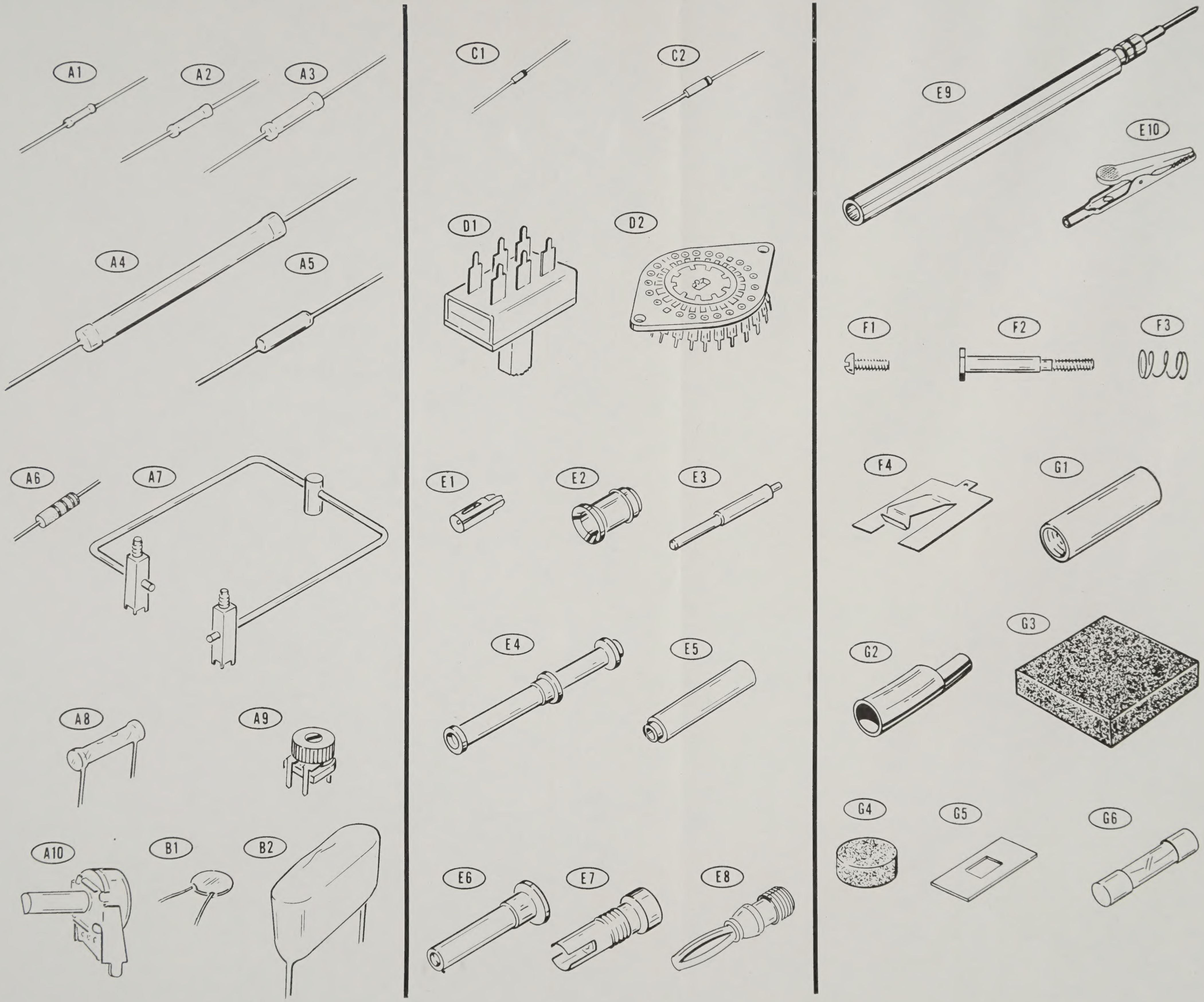
OR CLOTH.



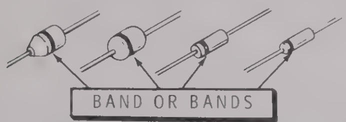


PARTS PICTORIAL



START

NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. THE CATHODE END OF THE DIODE IS MARKED WITH A BAND OR BANDS. ALWAYS POSITION THIS END AS SHOWN IN THE PICTORIAL.



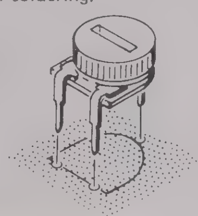
( ) Diode GD510 (#56-89) at D2.

( ) Diode GD510 (#56-89) at D1.

NOTE: Avoid excessive heat when soldering the diode leads to the foil.

( ) Solder the diode leads to the foil and cut off the excessive lead lengths.

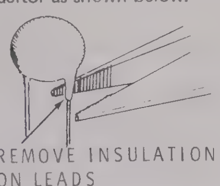
Two trimmers will be installed in the following steps. Install each trimmer as shown. Then bend each lug on the foil side of the circuit board to hold the trimmer in position for soldering.



( ) 2200 Ω (2 k 2) trimmer (#10-368).

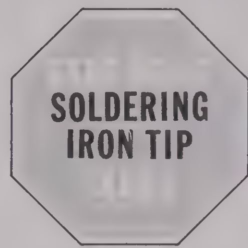
( ) 4700 Ω (4 k 7) trimmer (#10-369).

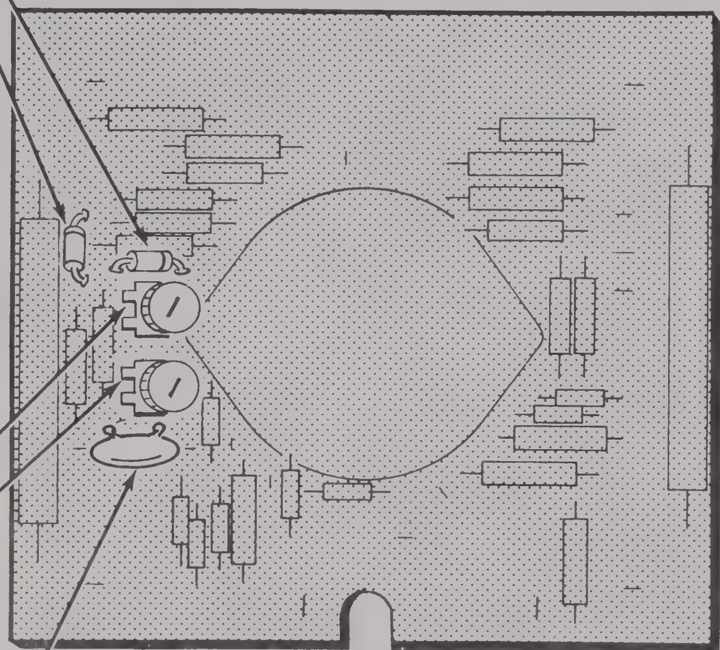
( ) Prepare the .02 μF disc capacitor. Use pliers to remove any insulation on the leads near the body of the capacitor as shown below.



( ) .02 μF disc capacitor.

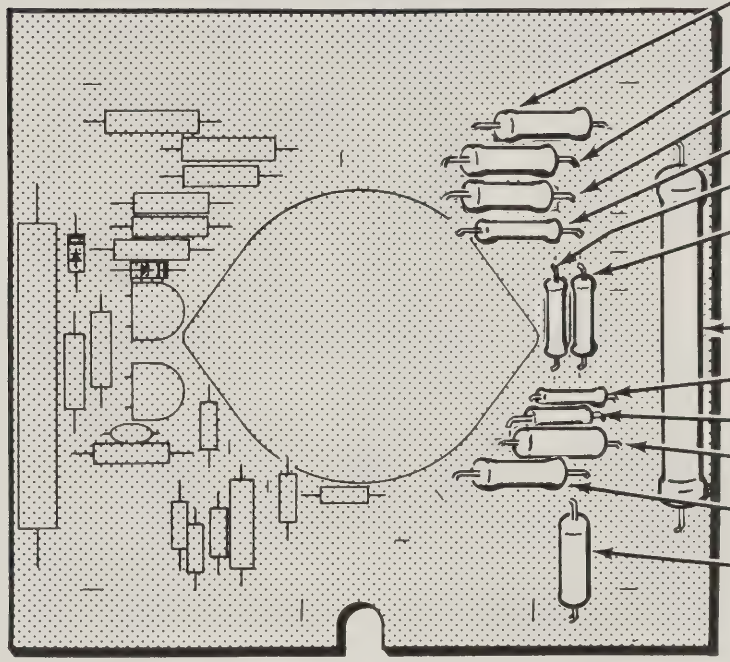
( ) Solder the leads to the foil and cut off the excess lead lengths.





PICTORIAL 1-3

START



( ) 10 MΩ resistor.

( ) 5 MΩ resistor.

( ) 4 MΩ resistor.

( ) 800 kΩ resistor.

( ) 45 kΩ resistor.

( ) 150 kΩ resistor.

( ) Solder all leads to the foil and cut off the excess lead lengths.

( ) 80 MΩ resistor.

( ) 236.8 Ω resistor.

( ) 23.68 Ω resistor.

( ) 2.106 Ω resistor.

( ) 19.5 Ω resistor.

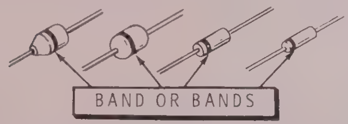
( ) .4997 Ω resistor.

( ) Solder all leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-2

START

NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. THE CATHODE END OF THE DIODE IS MARKED WITH A BAND OR BANDS. ALWAYS POSITION THIS END AS SHOWN IN THE PICTORIAL.



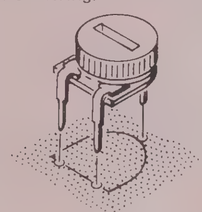
( ) Diode GD510 (#56-89) at D2.

( ) Diode GD510 (#56-89) at D1.

NOTE: Avoid excessive heat when soldering the diode leads to the foil.

( ) Solder the diode leads to the foil and cut off the excessive lead lengths.

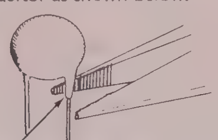
Two trimmers will be installed in the following steps. Install each trimmer as shown. Then bend each lug on the foil side of the circuit board to hold the trimmer in position for soldering.



( ) 2200 Ω (2 k 2) trimmer (#10-368).

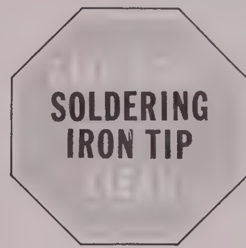
( ) 4700 Ω (4 k 7) trimmer (#10-369).

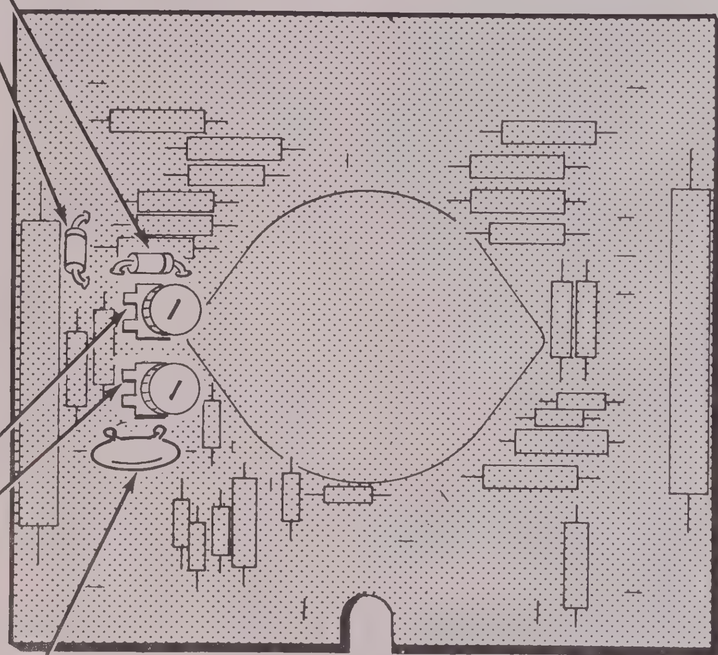
( ) Prepare the .02 μF disc capacitor. Use pliers to remove any insulation on the leads near the body of the capacitor as shown below.



( ) .02 μF disc capacitor.

( ) Solder the leads to the foil and cut off the excess lead lengths.



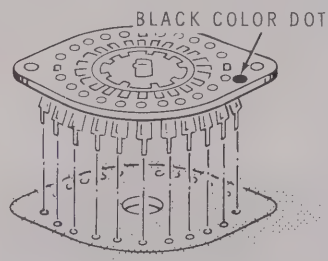


PICTORIAL 1-3

START

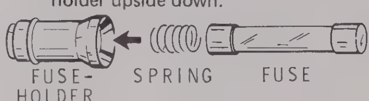
The rear wafer switch will be mounted in the following steps. Make sure the black color dot is positioned as shown in the Pictorial.

( ) Rear wafer switch. Mount the switch as shown below. Be sure each pin penetrates the circuit board and extends through the foil side.

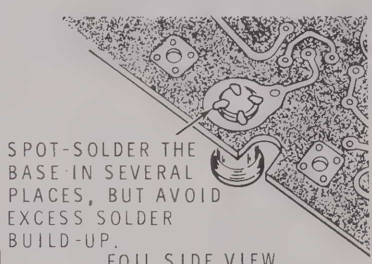


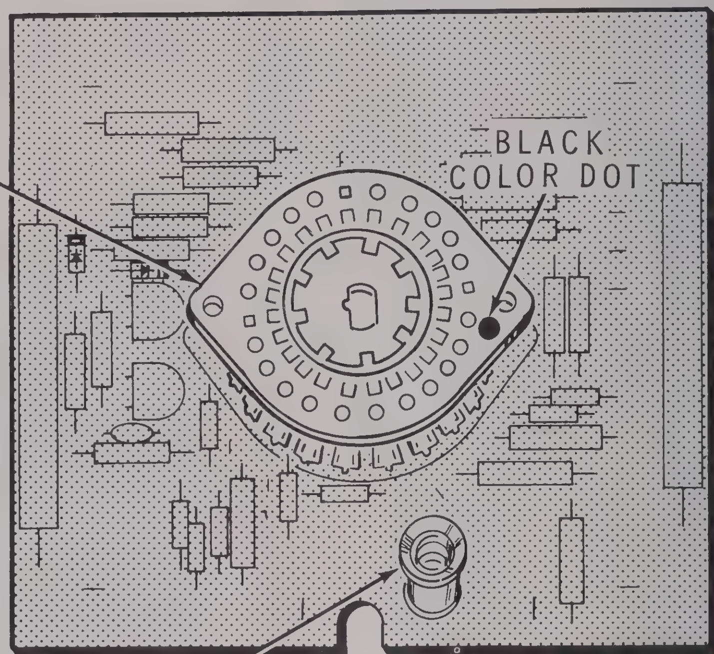
( ) Solder the switch pins to the foil side.

( ) Insert the coil spring into the fuseholder as shown below. Use the fuse to force the spring all the way down into the fuseholder; then exert a slight twisting motion to lock the spring in place. Check to be sure the spring is locked by turning the fuseholder upside down.



( ) Install the fuseholder. Be sure the fuseholder is perpendicular to the board. Then, solder its base to the foil as shown below.



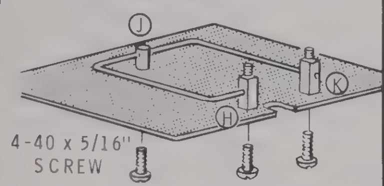


PICTORIAL 1-4

START

( ) Position the rear circuit board as shown in Pictorial 1-5.

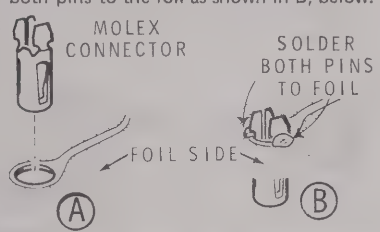
( ) Mount the .0263 Ω shunt with three 4-40 x 5/16" screws at J, H, and K. Insert the screws from the foil side as shown below.



( ) Check to insure that the screws at H and K are snug against the foil and making good electrical contact.

( ) Position the front circuit board (#85-526) as shown in Pictorial 1-6.

In the following steps, you will be instructed to install seven Molex connectors on the front circuit board. Insert each connector from the foil side as shown in A, below. Make sure each connector is perpendicular to the board and that both pins are open and straight. Then solder both pins to the foil as shown in B, below.



( ) Connector at B.

( ) Connector at F.

( ) Connector at A.

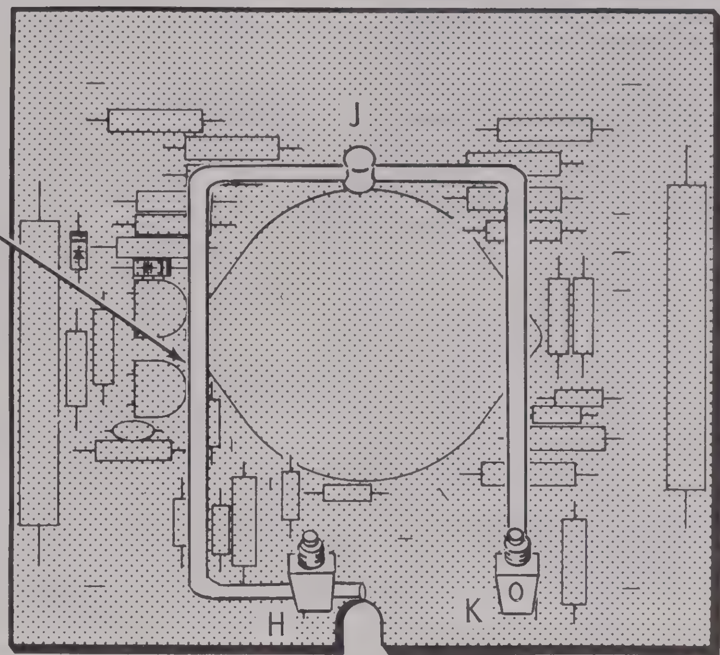
( ) Connector at E.

( ) Connector at G.

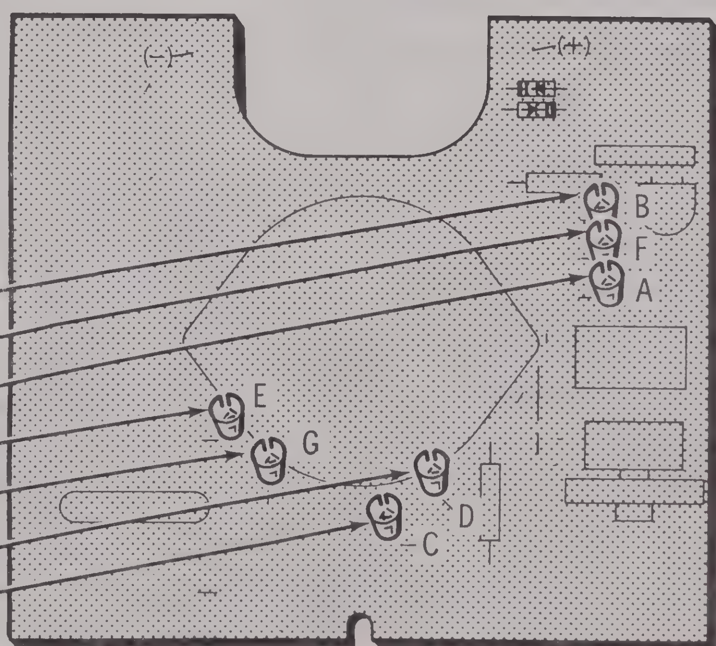
( ) Connector at D.

( ) Connector at C.

( ) Check to insure that all 7 Molex connectors have been soldered and that no solder bridges exist between the foils.



PICTORIAL 1-5

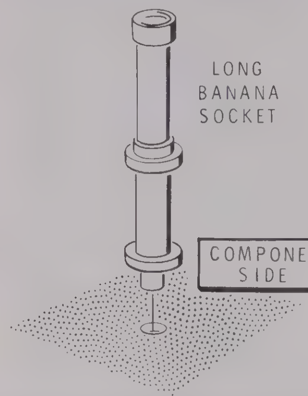


PICTORIAL 1-6

START

( ) Place the rear circuit board foil side down on your table or work bench.

In the following steps, you will be instructed to insert four long banana sockets into the rear circuit board. Insert each banana socket from the component side as shown below. Do not solder the banana sockets until instructed to do so.

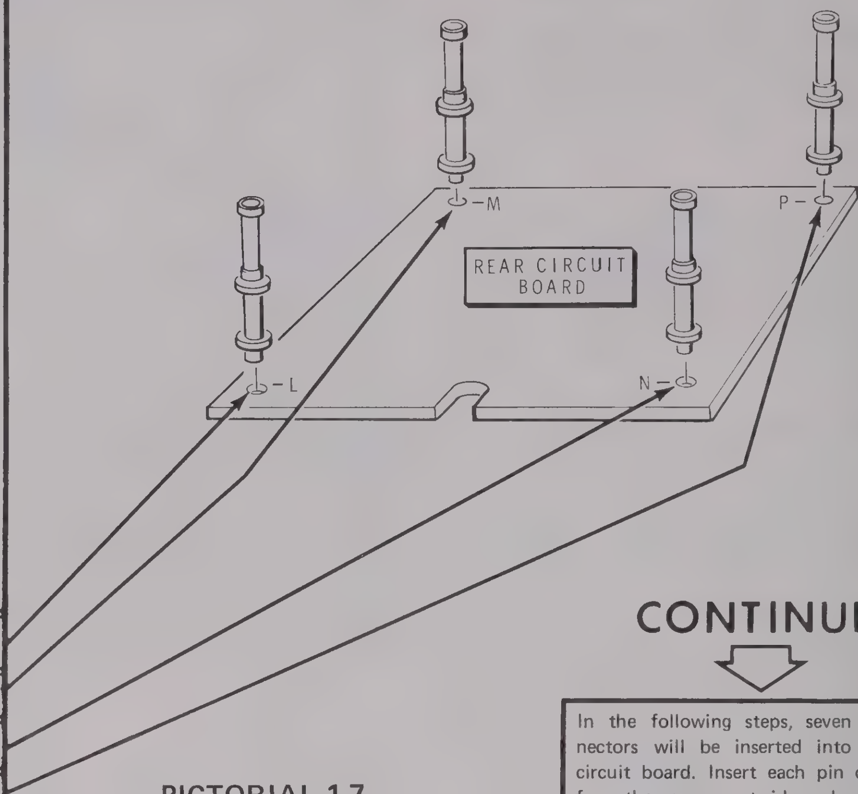


( ) Banana socket at L.

( ) Banana socket at M.

( ) Banana socket at N.

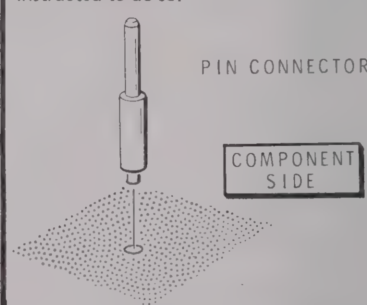
( ) Banana socket at P.



PICTORIAL 1-7

CONTINUE

In the following steps, seven pin connectors will be inserted into the rear circuit board. Insert each pin connector from the component side as shown below. Do not solder the pin connectors until instructed to do so.



( ) Pin connector at B.

( ) Pin connector at F.

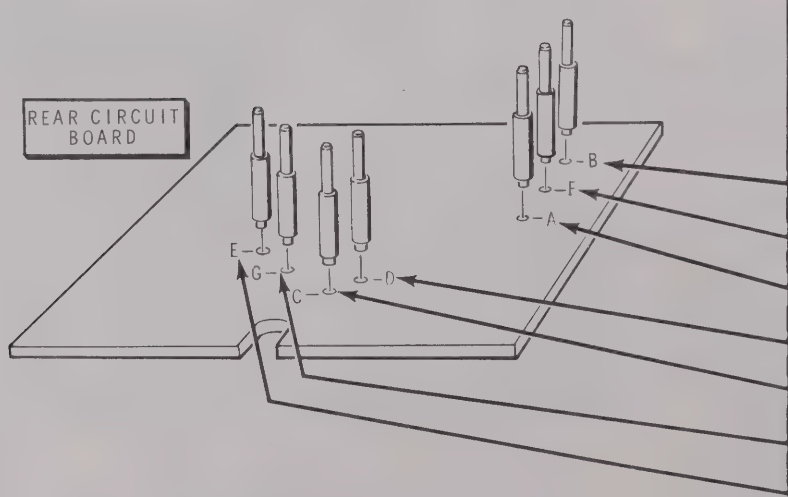
( ) Pin connector at A.

( ) Pin connector at D.

( ) Pin connector at C.

( ) Pin connector at G.

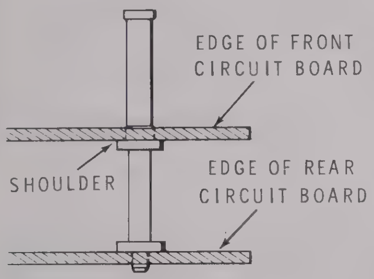
( ) Pin connector at E.

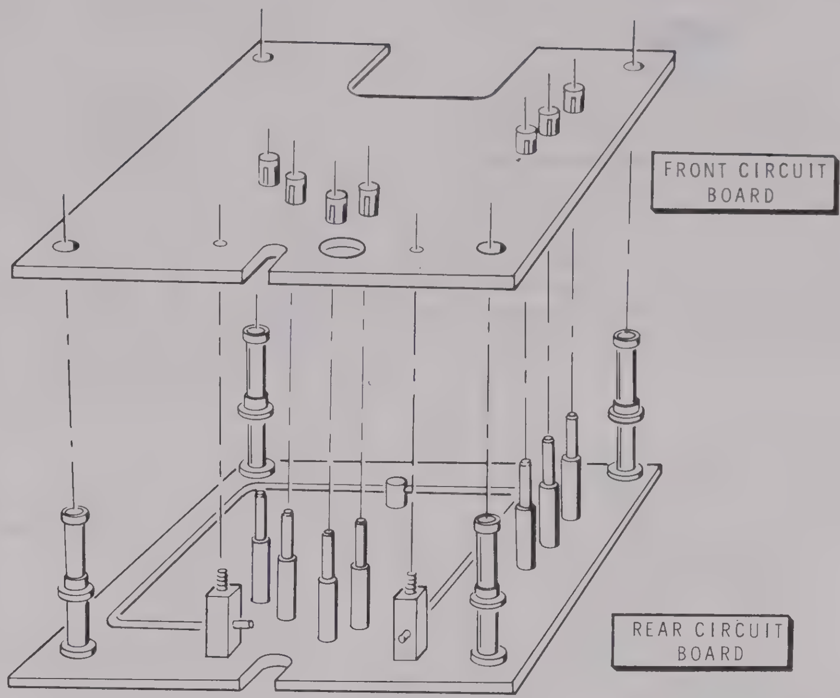


PICTORIAL 1-8

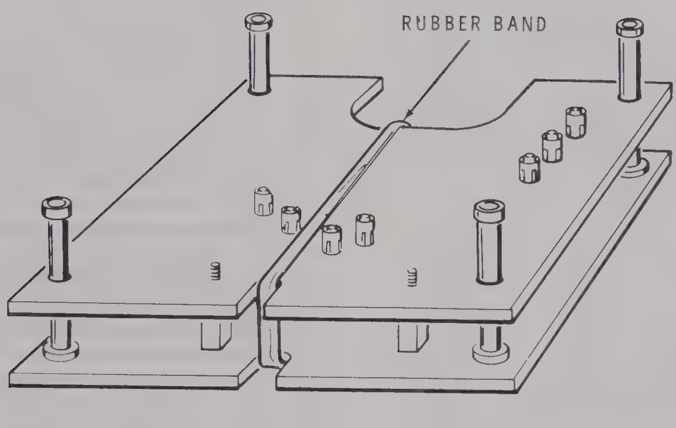
START

( ) Refer to the Pictorial and temporarily mount the two circuit boards together. Guide the four banana sockets through their corresponding holes on the front circuit board. Be sure that the threaded portions of the shunt posts at H and K penetrate their corresponding holes in the front circuit board and that all seven pin connectors penetrate their Molex connectors. Then firmly press the boards together until the front circuit board is against the shoulder of each banana socket as shown below.





PICTORIAL 1-9



PICTORIAL 1-10

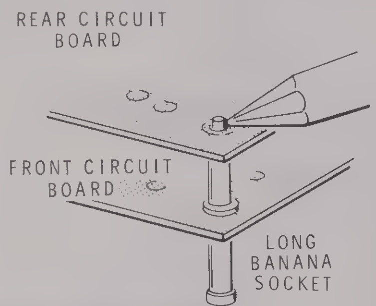
CONTINUE

( ) Again check that the front circuit board is seated against the shoulder of each banana socket and that all seven pin connectors penetrated their Molex connectors. Then, holding the two boards firmly together, place a rubber band (supplied in the packaging material) around both boards as shown.

START

( ) Place the two circuit boards foil side up on your table or work bench.

In the following steps, you will be instructed to solder the four long banana sockets to the foil of the rear circuit board. Be sure that each socket is firmly seated. Then hold your soldering iron in the position shown below to sufficiently heat the banana socket as well as the foil.

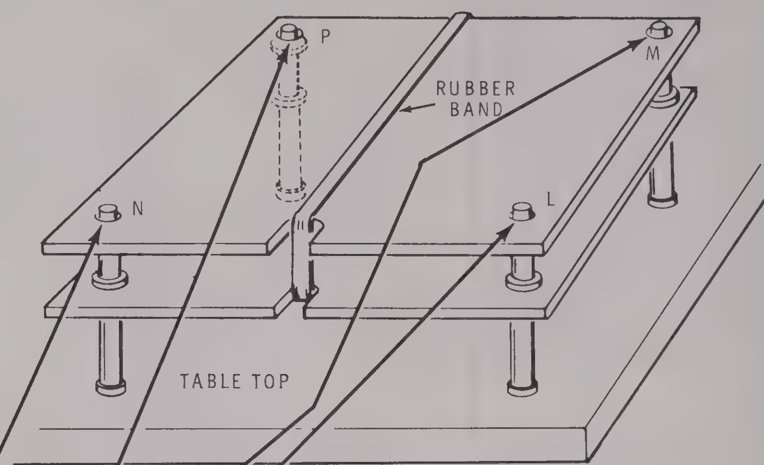


( ) Solder the socket at N.

( ) Solder the socket at P.

( ) Solder the socket at M.

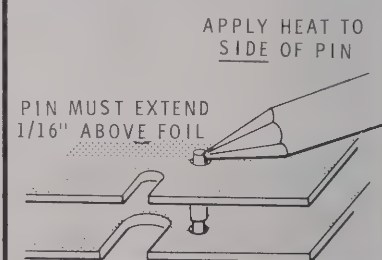
( ) Solder the socket at L.



PICTORIAL 1-11

CONTINUE

In the following steps, you will be instructed to solder the seven connector pins to the foil of the rear circuit board. CAUTION: Be sure that each connector pin extends 1/16" above the rear circuit board foil. Then hold your soldering iron in the position shown below to sufficiently heat the connector pin and the foil without pushing the pin down.



( ) Solder the pin at B.

( ) Solder the pin at F.

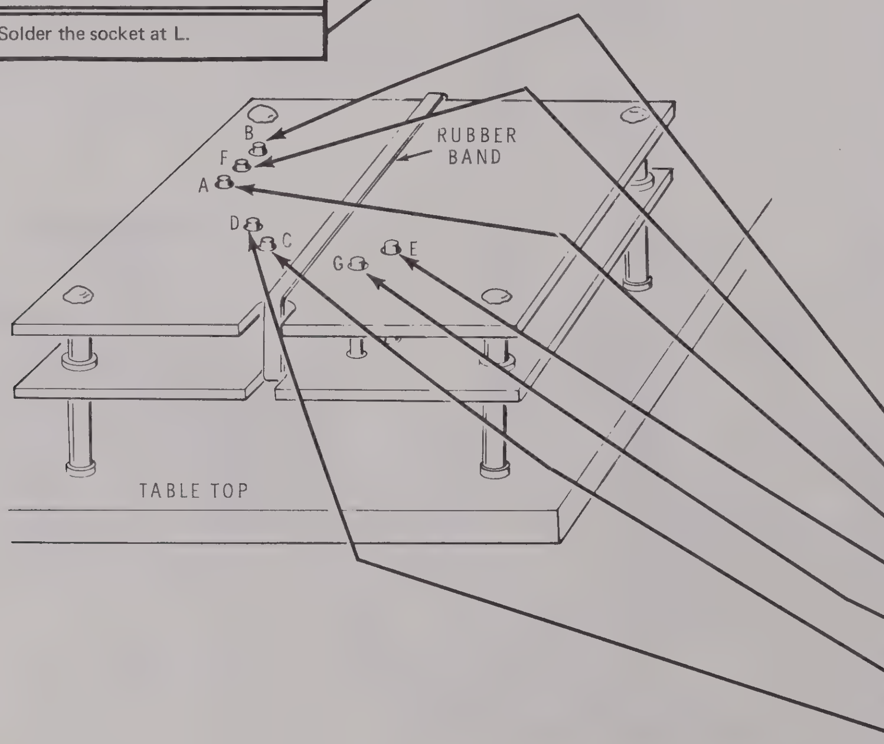
( ) Solder the pin at A.

( ) Solder the pin at E.

( ) Solder the pin at G.

( ) Solder the pin at C.

( ) Solder the pin at D.



PICTORIAL 1-12

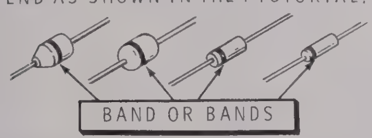
START

( ) Remove the rubber band from the two circuit boards. Then, grasping one circuit board in each hand, carefully separate the two boards.

( ) Check to insure that each of the seven connectors and four long banana sockets are firmly seated and well soldered to the foil of the rear circuit board. Then set the rear circuit board aside temporarily.

( ) Position the front circuit board (#85-526) as shown in Pictorial 2-1. Then complete each step on Pictorial 2-1.

NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. THE CATHODE END OF THE DIODE IS MARKED WITH A BAND OR BANDS. ALWAYS POSITION THIS END AS SHOWN IN THE PICTORIAL.



( ) Diode 1N4149 (#56-56) at D3.

( ) Diode 1N4149 (#56-56) at D4.

( ) 1500 Ω thermistor.

( ) 1350 Ω (1.35 kΩ) resistor.

( ) 1000 Ω (1 k 0) trimmer (#10-367).

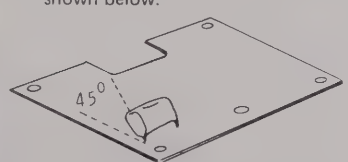
( ) Remove the insulation from a 1" length of green hookup wire. Then install this wire as a jumper.

( ) .22 μF Mylar capacitor.

( ) 11 kΩ (brown-black-orange) resistor.

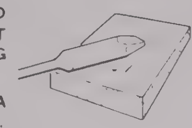
( ) Solder all leads to the foil and cut off the excess lead lengths.

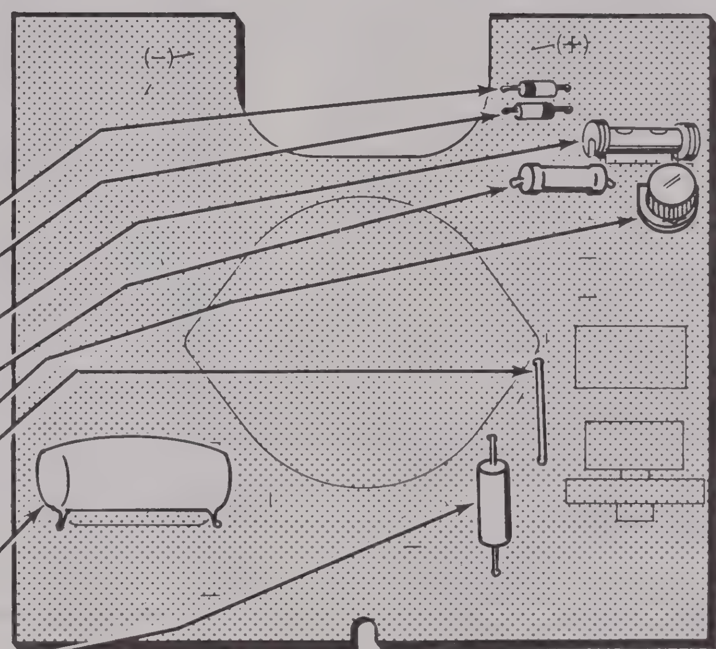
( ) After soldering, bend the .22 μF Mylar capacitor back to form about a 45 degree angle with the board as shown below.



FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN...

WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.



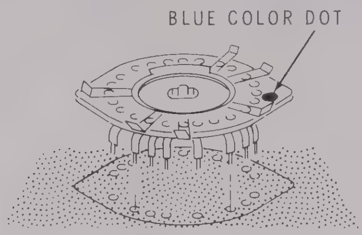


PICTORIAL 2-1

START

The front wafer switch will be mounted in the following steps. Make sure the blue color dot is positioned as shown in the Pictorial.

( ) Front wafer switch S2. Mount the switch as shown below. Be sure each pin penetrates the circuit board and extends through the foil side.



( ) Solder the switch pins to the foil side.

NOTE: To prepare a wire, cut it to the indicated length and cut 1/4" of insulation from each end.

( ) Prepare the following lengths of hookup wire.

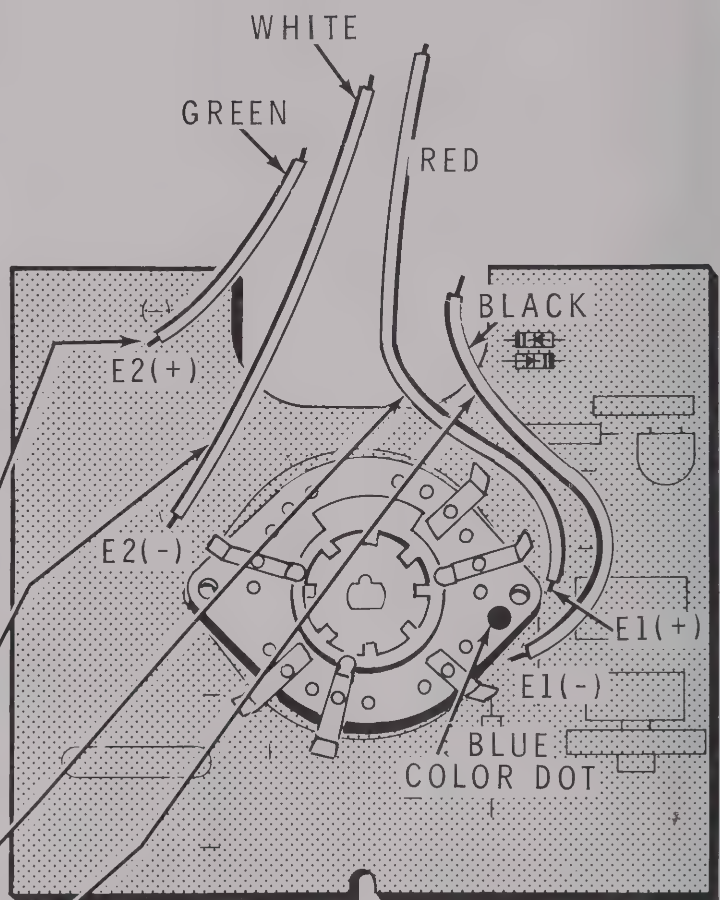
4" green
5-1/2" white
7" red
5-3/4" black

( ) Solder the 4" green wire to the foil at E2 (+). The other end of this wire will be connected later.

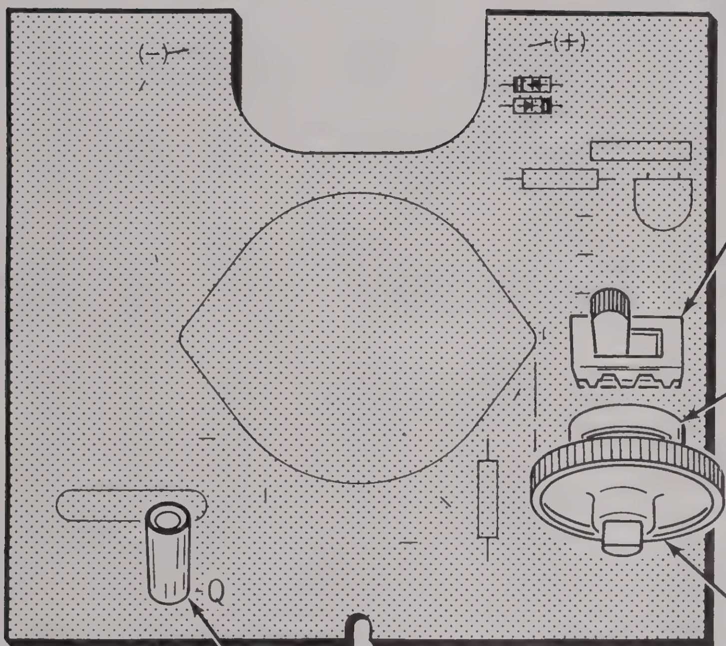
( ) Solder the 5-1/2" white wire to the foil at E2 (-). The other end of this wire will be connected later.

( ) Solder the 7" red wire to the foil at E1 (+). The other end of this wire will be connected later.

( ) Solder the 5-3/4" black wire to the foil at E1 (-). The other end of this wire will be connected later.

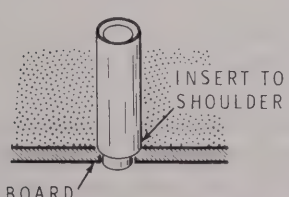


PICTORIAL 2-2



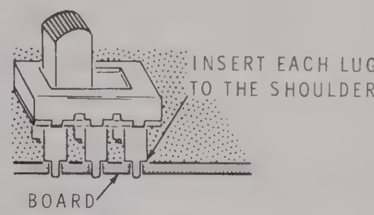
START

( ) Short banana socket at Q. Make sure the socket is firmly seated on the board as shown below. Then solder the socket to the foil.

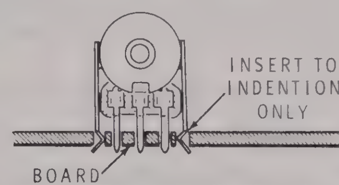


CONTINUE

( ) Slide switch. Make sure the switch is firmly seated on the board as shown below. Then solder the 6 lugs to the foil.

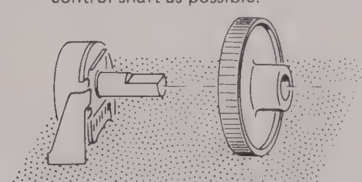


( ) 100 kΩ control (#10-363). Press in on the sides of the control and insert the lugs through the board ONLY AS FAR AS THE INDENTION shown below. Make sure that all the lugs penetrate to the foil side. Then solder the 5 lugs to the foil.



NOTE: The thumbwheel used in the following steps is packaged inside the meter case. Use a coin to unscrew the thumbnut holding the rear panel onto the back of the meter case. Use the hexagon end of the thumbnut to slightly lift the panel; then slide the panel off toward the bottom of the case.

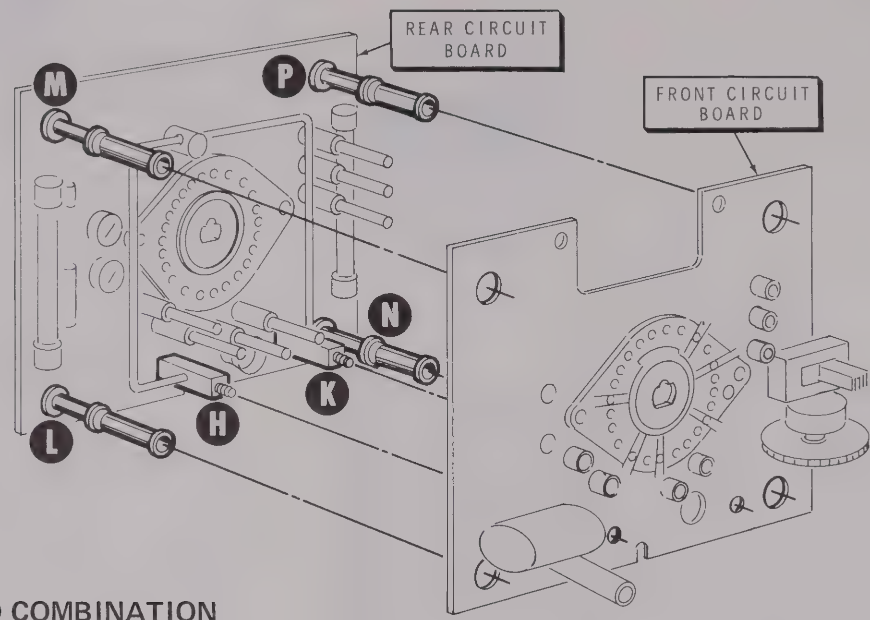
( ) Mount the thumbwheel on the control shaft as shown below. Push the thumbwheel as far onto the control shaft as possible.



( ) This completes the assembly of the front circuit board. Check to see that all connections are soldered and that no solder bridges exist.

FINISH

PICTORIAL 2-3



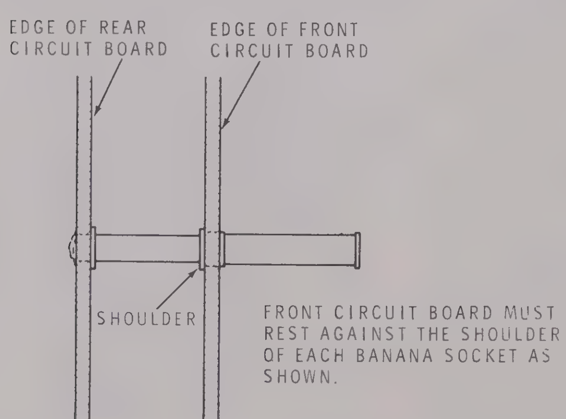
PICTORIAL 3

CIRCUIT BOARD COMBINATION

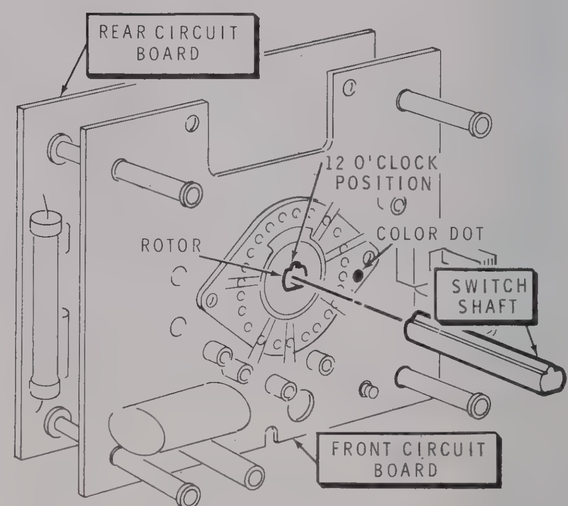
Refer to Pictorial 3 for the following steps.

( ) Position the two circuit boards as shown in the Pictorial.

( ) Mount the two circuit boards together by guiding the banana sockets at M, P, L, and N on the rear circuit board through their corresponding holes in the front circuit board. Be sure that the threaded portion of the shunt posts at H and K penetrate their corresponding holes in the front circuit board and that all 7 pin connectors connect with their Molex sockets. Then firmly press the boards together until the front circuit board is against the shoulder of each banana socket as shown in Detail 3-1.



Detail 3-1



Detail 3-2

NOTE: The switch shaft used in the following step is packaged inside the meter case.

( ) Refer to Detail 3-2 and insert the switch shaft through the center hole of both switch rotors. Turn the shaft to align both rotors to the 12 o'clock position as shown in the Detail. Then carefully remove the shaft without disturbing the rotors.

CASE ASSEMBLY

Refer to Pictorial 4 (fold-out from Page 19) for the following steps.

( ) Remove and discard the shorting clip attached between the two meter terminals at AH and AJ.

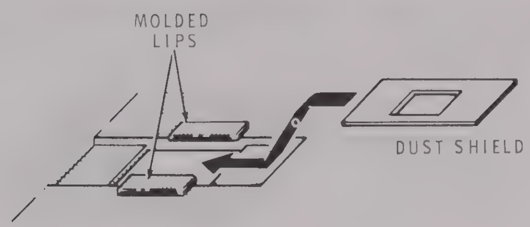
CAUTION: In the following step, do not apply excess pressure to the back of the switch knob. To do so, may force the knob out of the case. If this should occur, refer to the "Case and Meter Replacement" paragraphs on Page 32 for instructions on how to reinstall the knob.

( ) Insert the switch shaft into the back of the case at AF. Force the shaft into position while applying pressure to the switch knob on the front of the case. Then turn the knob to align the shaft to the 12 o'clock position as shown in the Pictorial.

CAUTION: In the following step make sure that the top edge of the large battery cushion does not interfere with closing the rear panel.

( ) Mount the large battery cushion at AA. Remove the protective paper backing and press the cushion into position.

( ) Mount the small battery cushion in the same manner at AC. Press hard to form the cushion into the curved bottom of the compartment.



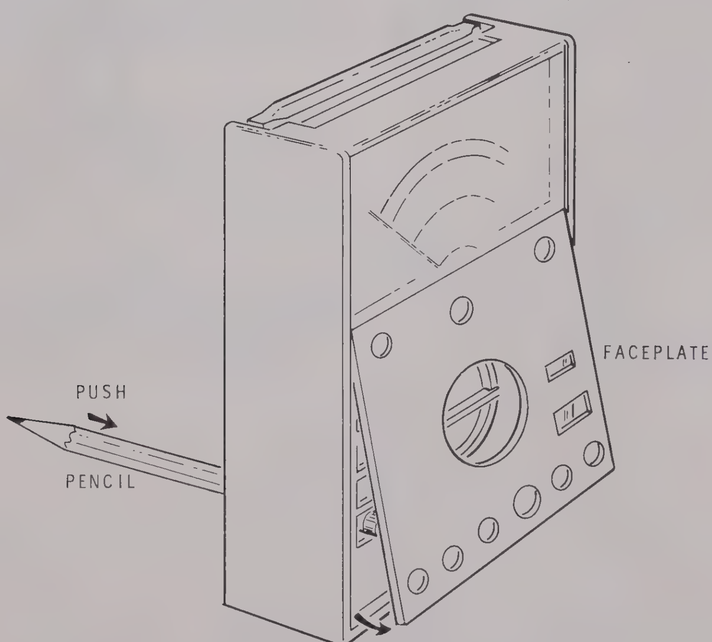
Detail 4-1

( ) Mount the plastic dust shield at AG. Refer to Detail 4-1 and slide the dust shield under the molded lips on the switch opening.

( ) Mount the BLK RED battery polarity label at AB. Remove the protective paper backing and press the label into position. Be sure to observe polarity marks.

( ) Mount the WHT GRN battery polarity label in the same manner at AD. Be sure to observe polarity marks.

( ) Refer to Detail 4-2 and use a good eraser end of a pencil to remove the plastic faceplate from the front of the case. Insert the eraser through the bottom square hole shown in the Pictorial at AE and, being careful not to scratch the paint backing, push on the pencil to pop off the friction-fit faceplate.



Detail 4-2

Refer to Pictorial 5 (fold-out from Page 19) for the following steps.

( ) Refer to inset drawing #2 and position the four battery wires at the bottom of the large cut-out section of the front circuit board. The exact positions of these wires are not critical as long as they do not cause any binding in the following step.

( ) Install the two circuit boards into the case by guiding them onto the switch shaft. Be sure that the slide switch penetrates the dust shield and that the thumbwheel centers through its opening on the front of the case. If necessary, remove the circuit boards and reposition the thumbwheel on its shaft to allow centering. When properly seated, the rear circuit board should rest flat against the back of the meter movement housing.

( ) Lock the circuit boards to the case with the two hexagon-head mounting screws at BE and BF. Start these screws but do not tighten.

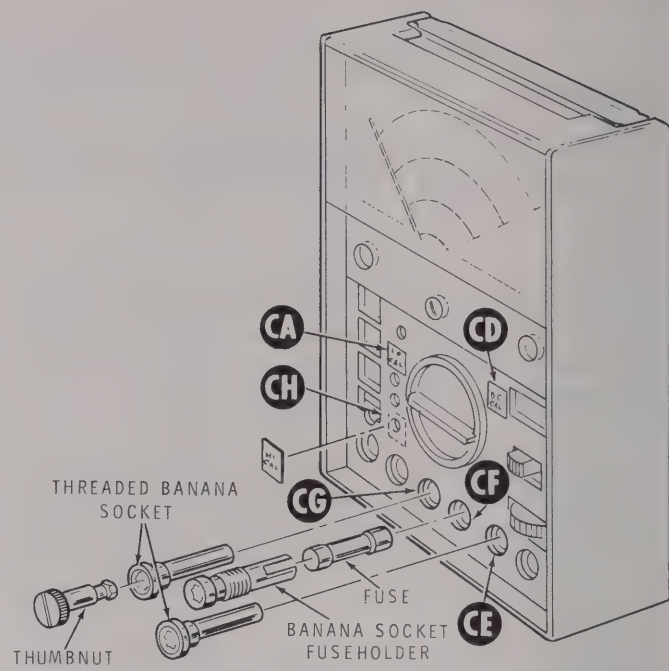
NOTE: In the following steps you will be instructed to solder the four battery wires to their respective clips. Complete each step in the following manner: Temporarily mount the clip as shown in the Pictorial. Be sure to mount the clip at BC in the position shown in inset drawing #1. Connect the proper battery wire to the clip's solder tab in a manner that will not interfere with battery installation or removal. Then slide the clip partially out of its holder and solder the connection. After the connection has cooled, slide the clip back to its original position.

( ) Solder the black wire to the clip at BA.

( ) Solder the red wire to the clip at BB.

( ) Solder the white wire to the clip at BC.

( ) Solder the green wire to the clip at BD.



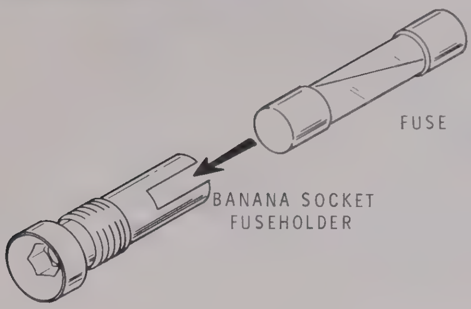
PICTORIAL 6

Refer to Pictorial 6 for the following steps.

NOTE: The thumbnut used to lock the rear panel of the case in position contains a hexagon socket drive on one end. Use this thumbnut as a tool to complete the following steps.

( ) Insert a threaded banana socket through the front of the case at CG. Then use the hexagon end of the thumbnut to tighten the socket into position.

( ) Insert the remaining threaded banana socket through the front of the case at CE. Then use the hexagon end of the thumbnut to tighten the socket into position.



Detail 6-1

( ) Refer to Detail 6-1 and press the fuse into the banana socket/fuseholder. Insert the socket and the fuse through the front of the case at CF. Then use the hexagon end of the thumbnut to tighten the socket into position.

( ) Mount the "LO CAL" label at CA. Remove the protective paper backing and press the label into position.

( ) Mount the "HI CAL" label at CH in the same manner.

( ) Mount the "DC CAL" label at CD in the same manner.

( ) Refer back to Pictorial 5 and tighten the two hexagon-head screws.

TEST LEADS PREPARATION

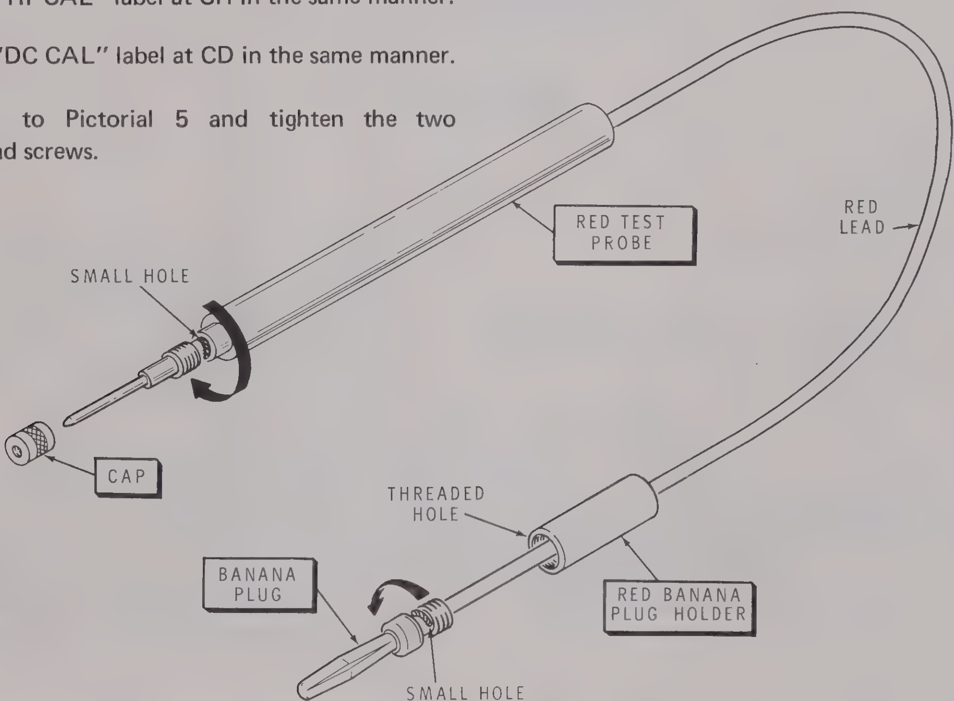
Refer to Pictorial 7 for the following steps.

( ) Remove 1/2" of insulation from both ends of the red test lead. Then twist together the strands of wire on each end of the lead.

( ) Unscrew the threaded cap from the red test probe.

( ) Install the red test probe on one end of the red test lead. Insert the lead through the probe until the stripped end protrudes through the hole in the metal shank. Wrap this wire around the shank in the direction of the arrow. Then screw the threaded cap into position.

( ) Install a banana plug on the other end of the red test lead. Insert the lead through the red holder and into the plug. Wrap the wire around the shank in the direction of the arrow. Then screw the holder onto the threaded portion of the plug.



PICTORIAL 7

Refer to Pictorial 5 (fold-out from Page 19) for the following steps.

( ) Refer to inset drawing #2 and position the four battery wires at the bottom of the large cut-out section of the front circuit board. The exact positions of these wires are not critical as long as they do not cause any binding in the following step.

( ) Install the two circuit boards into the case by guiding them onto the switch shaft. Be sure that the slide switch penetrates the dust shield and that the thumbwheel centers through its opening on the front of the case. If necessary, remove the circuit boards and reposition the thumbwheel on its shaft to allow centering. When properly seated, the rear circuit board should rest flat against the back of the meter movement housing.

( ) Lock the circuit boards to the case with the two hexagon-head mounting screws at BE and BF. Start these screws but do not tighten.

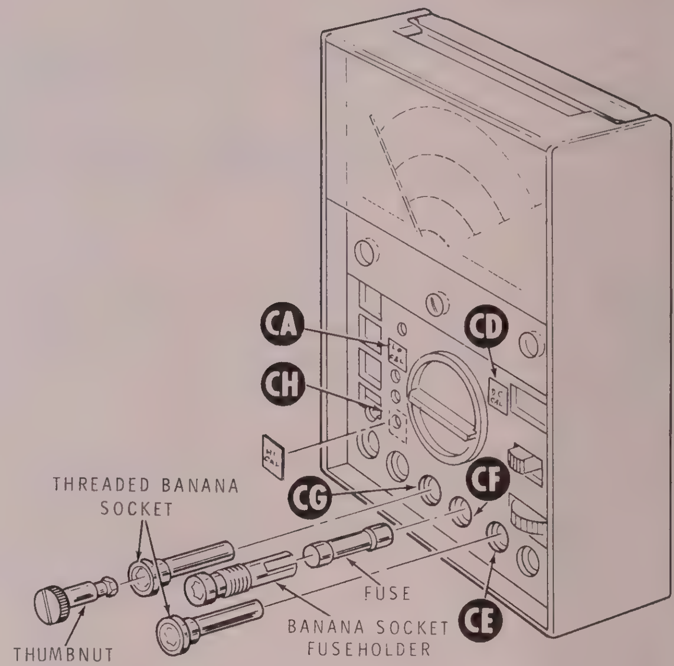
NOTE: In the following steps you will be instructed to solder the four battery wires to their respective clips. Complete each step in the following manner: Temporarily mount the clip as shown in the Pictorial. Be sure to mount the clip at BC in the position shown in inset drawing #1. Connect the proper battery wire to the clip's solder tab in a manner that will not interfere with battery installation or removal. Then slide the clip partially out of its holder and solder the connection. After the connection has cooled, slide the clip back to its original position.

( ) Solder the black wire to the clip at BA.

( ) Solder the red wire to the clip at BB.

( ) Solder the white wire to the clip at BC.

( ) Solder the green wire to the clip at BD.



PICTORIAL 6

Refer to Pictorial 6 for the following steps.

NOTE: The thumbnut used to lock the rear panel of the case in position contains a hexagon socket drive on one end. Use this thumbnut as a tool to complete the following steps.

( ) Insert a threaded banana socket through the front of the case at CG. Then use the hexagon end of the thumbnut to tighten the socket into position.

( ) Insert the remaining threaded banana socket through the front of the case at CE. Then use the hexagon end of the thumbnut to tighten the socket into position.

LEADS PREPARATION

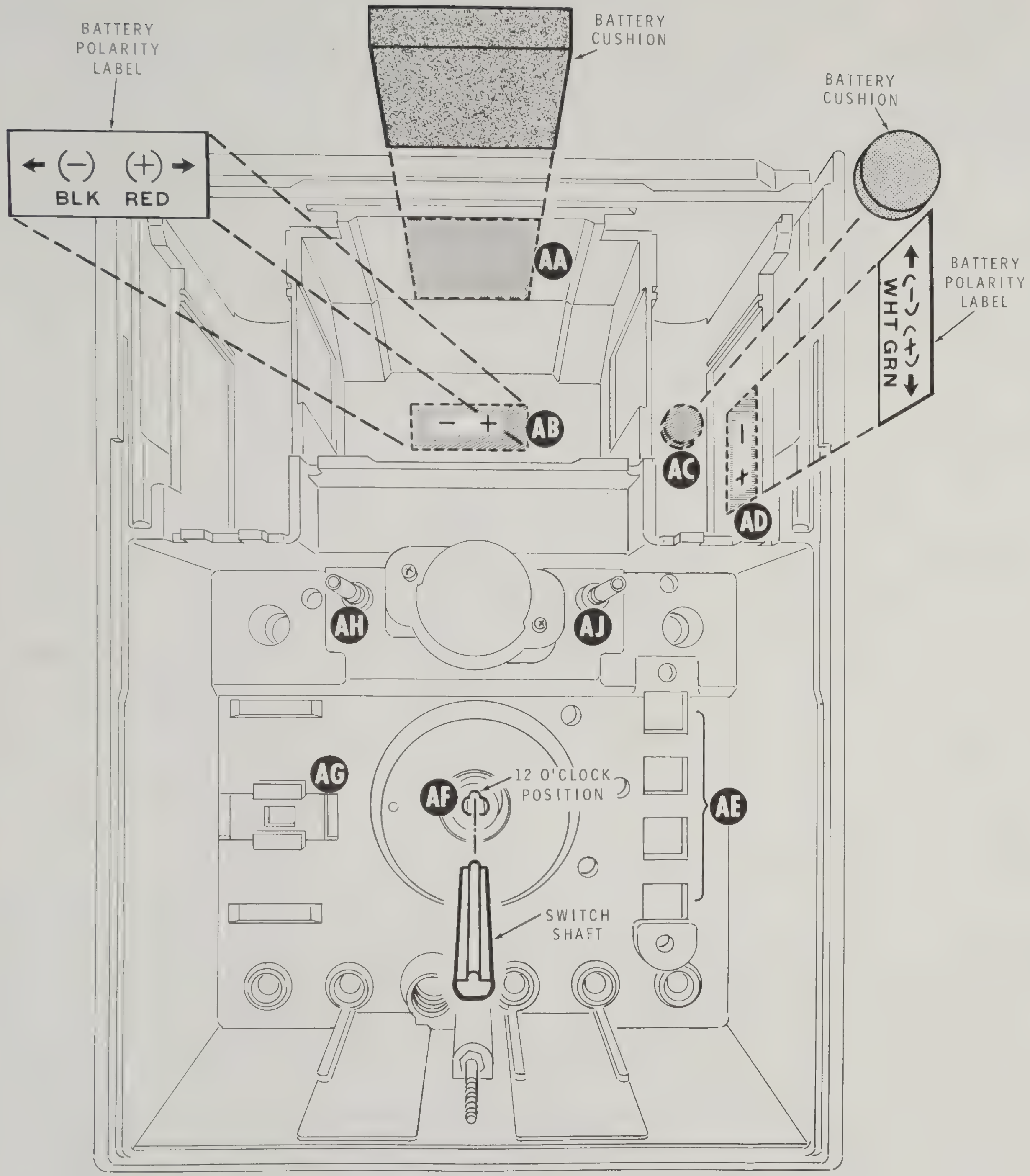
Pictorial 7 for the following steps.

emove 1/2" of insulation from both ends of the red st lead. Then twist together the strands of wire on ch end of the lead.

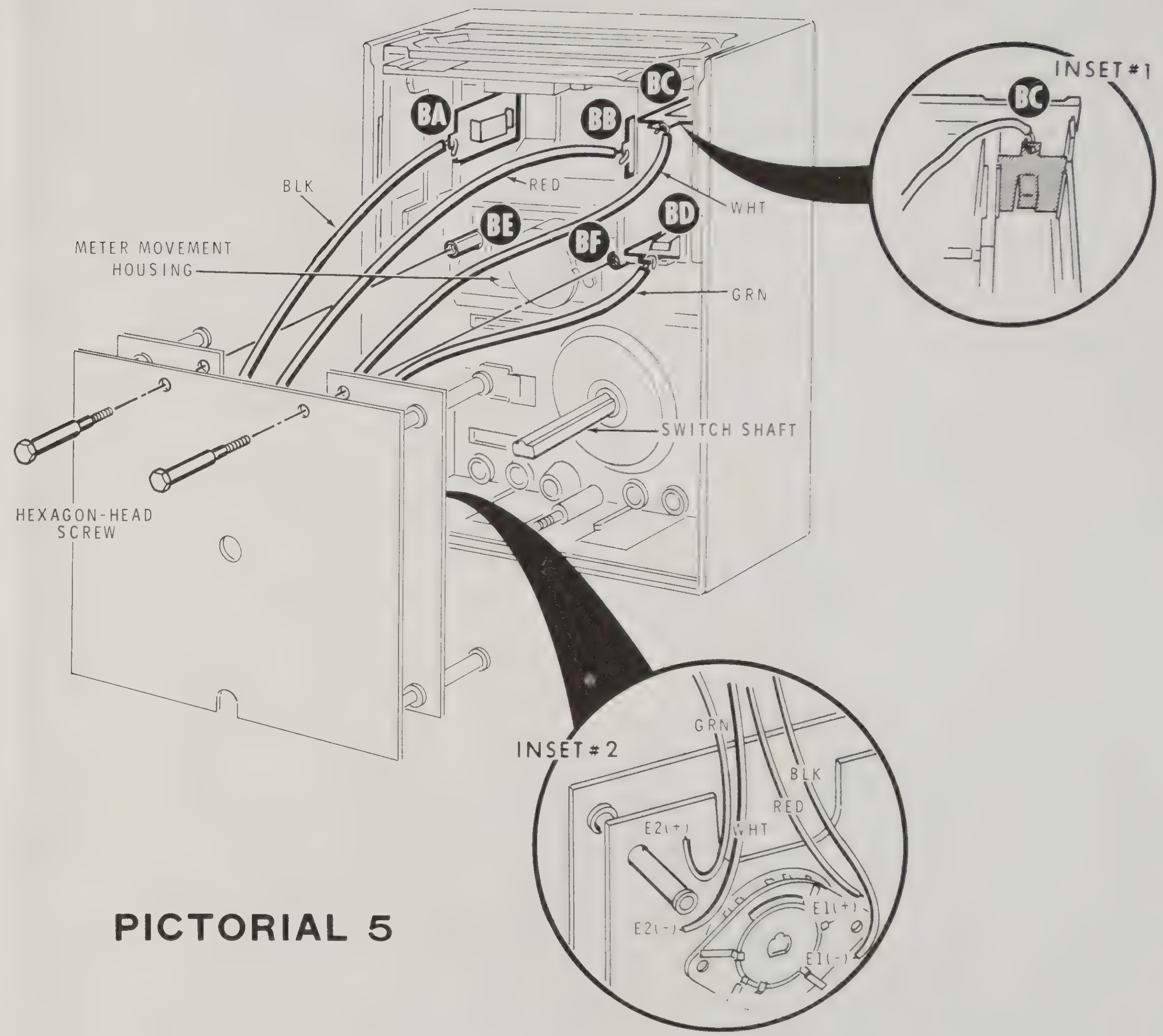
nscrew the threaded cap from the red test probe.

stall the red test probe on one end of the red test ad. Insert the lead through the probe until the ripped end protrudes through the hole in the metal ank. Wrap this wire around the shank in the rection of the arrow. Then screw the threaded cap to position.

stall a banana plug on the other end of the red test ad. Insert the lead through the red holder and into e plug. Wrap the wire around the shank in the rection of the arrow. Then screw the holder onto the readed portion of the plug.



PICTORIAL 4



PICTORIAL 5

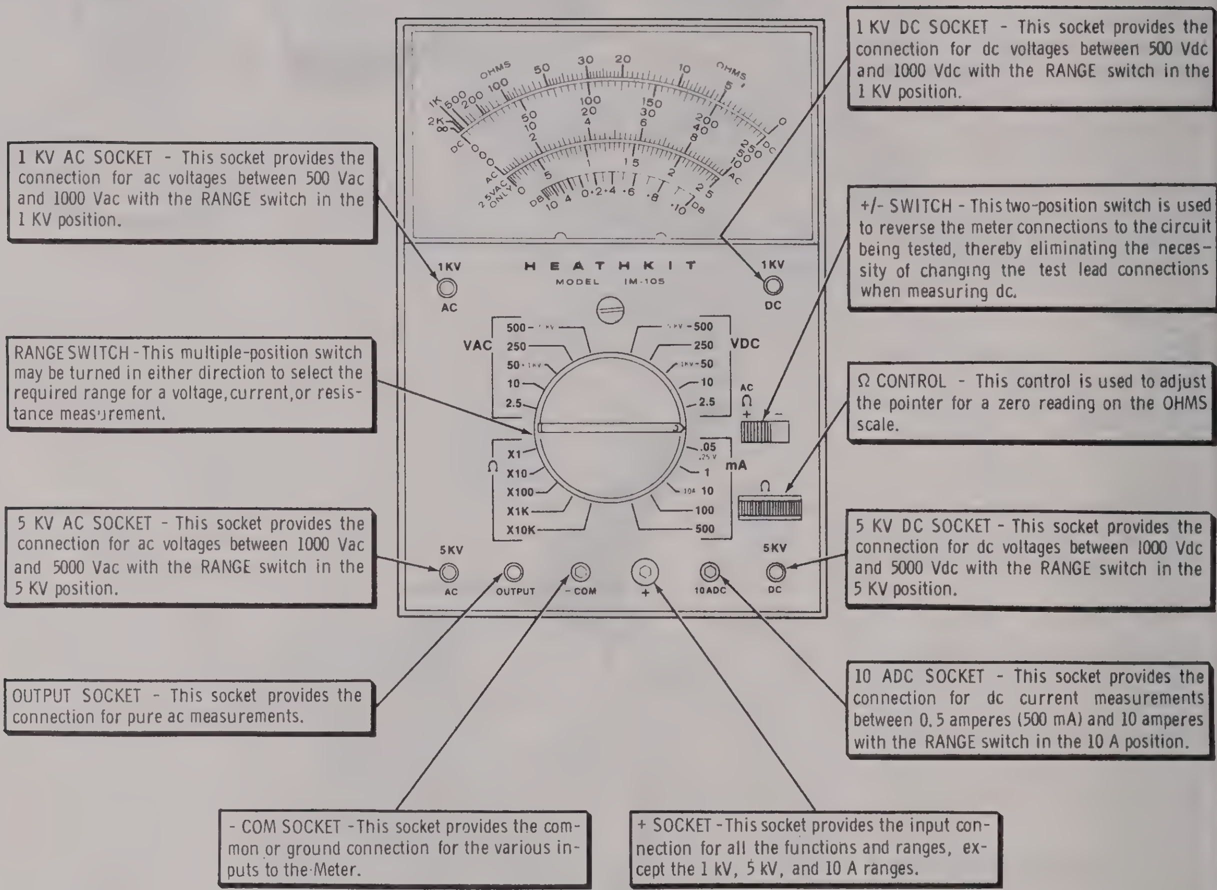

1 KV DC SOCKET - This socket provides the connection for dc voltages between 500 Vdc and 1000 Vdc with the RANGE switch in the 1 KV position.
1 KV AC SOCKET - This socket provides the connection for ac voltages between 500 Vac and 1000 Vac with the RANGE switch in the 1 KV position.
+/- SWITCH - This two-position switch is used to reverse the meter connections to the circuit being tested, thereby eliminating the necessity of changing the test lead connections when measuring dc.
RANGE SWITCH - This multiple-position switch may be turned in either direction to select the required range for a voltage, current, or resistance measurement.
Ω CONTROL - This control is used to adjust the pointer for a zero reading on the OHMS scale.
5 KV AC SOCKET - This socket provides the connection for ac voltages between 1000 Vac and 5000 Vac with the RANGE switch in the 5 KV position.
5 KV DC SOCKET - This socket provides the connection for dc voltages between 1000 Vdc and 5000 Vdc with the RANGE switch in the 5 KV position.
OUTPUT SOCKET - This socket provides the connection for pure ac measurements.
10 ADC SOCKET - This socket provides the connection for dc current measurements between 0.5 amperes (500 mA) and 10 amperes with the RANGE switch in the 10 A position.
- COM SOCKET - This socket provides the common or ground connection for the various inputs to the Meter.
+ SOCKET - This socket provides the input connection for all the functions and ranges, except the 1 kV, 5 kV, and 10 A ranges.
HEATHKIT
MODEL IM-105
1KV
AC
1KV
DC
VAC
VDC
mA
5KV
AC
5KV
DC
OUTPUT
- COM
+
10 ADC

FIGURE 2

CALIBRATION

This section of the Manual contains two calibration procedures. If you have access to a precision standard, proceed with the "Precision Calibration" section on Page 22. If a precision standard is not available, proceed with the following "Basic Calibration" section.

BASIC CALIBRATION

The accuracy of your Meter depends to a great extent upon the care and accuracy that you exercise in performing the following steps. These steps are designed to require only a minimum of equipment to calibrate the ac and dc sections of your Meter. If you do not know how to read the meter scales, the instructions under "Reading the Meter" on Page 24 before proceeding with this Calibration.

If at any time you do not obtain the results called for in a step, refer to the "In Case of Difficulty" section on Page 35 to correct the problem.

Refer to Figure 1 (fold-out from Page 20) for the following steps.

ZERO ADJUST

( ) Check the zero position of the meter pointer. If the pointer does not rest directly over the zero marks at the left end of the meter scales, carefully turn the meter ZERO ADJUST screw at CB to bring the pointer over the zero marks. Tapping the face of the meter is not necessary while positioning the ZERO ADJUST due to the frictionless characteristics of the movement.

DC CALIBRATION

NOTE: The adjustments required in the following steps make it necessary to leave the faceplate off of the meter case. In order to know the locations of the various range-positions and plugs called for in the following steps, temporarily lay the faceplate over the RANGE switch to verify the positions.

( ) Connect the banana plug on the red test lead to the + socket.

( ) Connect the banana plug on the black test lead to the – COM socket.

( ) Turn the RANGE switch to the 1.0 mA position.

( ) Position the +/–switch to the + position.

( ) Attach the alligator clip on the black test lead to one lead of the remaining 1.35 kΩ resistor.

( ) Hold the other lead of the 1.35 kΩ resistor against the negative (-) end of the 1.5-volt, D-cell battery, and hold the tip of the red test probe against the positive (+) end of the battery. Hold these connections together between the thumb and index finger of one hand and read the scale. The pointer should show an approximate full-scale reading. Insert a 1/8" blade screwdriver through the rectangular hole marked "DC CAL" and adjust the control (R32 on the schematic) for a reading of 0.969 mA.

AC CALIBRATION

WARNING: Use extreme care when measuring line voltage to prevent personal shock or instrument damage.

High Range

( ) Turn the RANGE switch to the 250 VAC position.

( ) If the cord for a waffle iron or other household appliance which connects to two round posts on the appliance is available, plug the test probe and the alligator clip into the round connectors on one end of the cord. Plug the other end of the cord into a household line voltage outlet. If no cord is available, attach the alligator clip to a known earth ground and insert the test probe directly into the outlet. If no indication of voltage is obtained on one side of the outlet, try the other side. The pointer should deflect upscale.

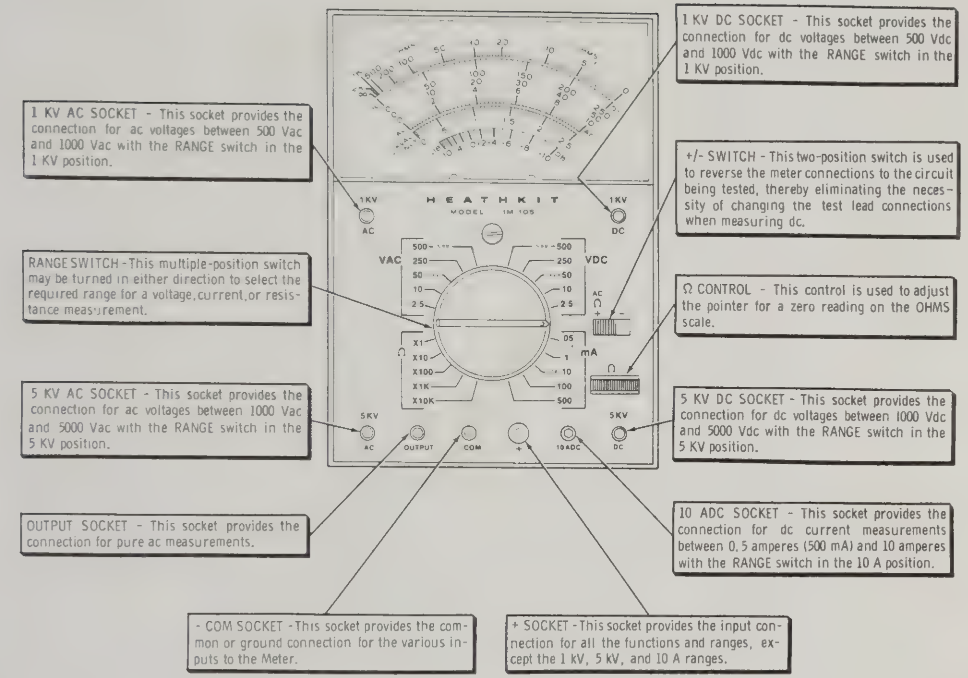


FIGURE 2

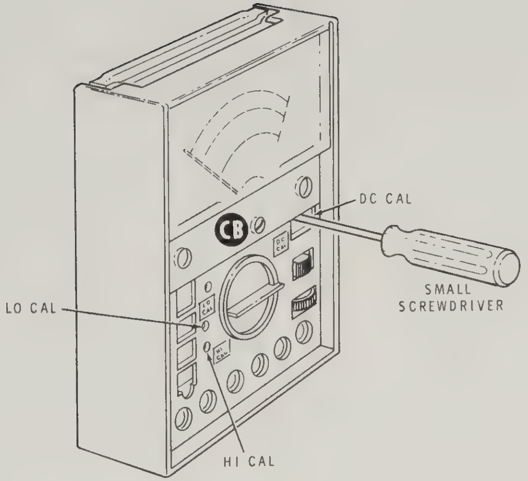
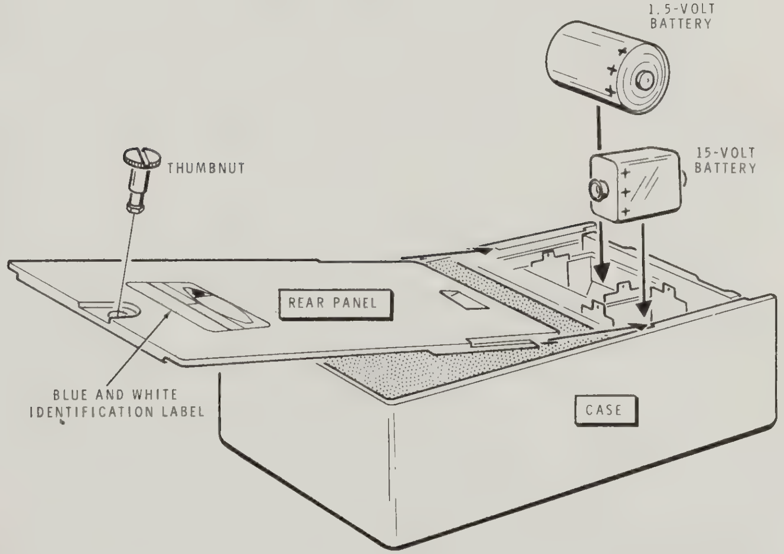
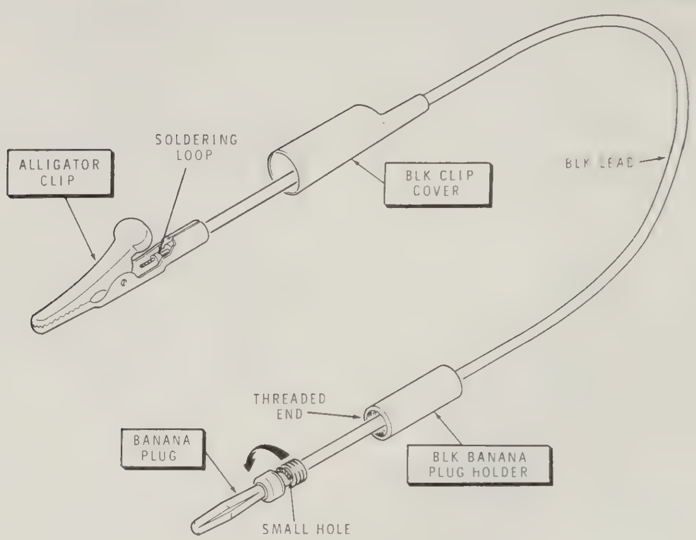


FIGURE 1



PICTORIAL 9



PICTORIAL 8

Refer to Pictorial 8 for the following steps.

( ) Remove 1/2" of insulation from both ends of the black test lead. Then twist together the strands of wire on each end of the lead.

( ) Install a banana plug on one end of the black test lead. Insert the lead through the black holder and into the plug. Wrap the wire around the shank in the direction of the arrow. Then screw the holder onto the threaded portion of the plug.

( ) Install the alligator clip and cover on the other end of the black test lead. Insert the lead through the cover and into the alligator clip. Then solder the bare wires to the soldering loop of the alligator clip. After the connection has cooled, slide the black clip cover over the alligator clip.

This completes the "Step-by-Step Assembly." You should have a 1.35 kΩ resistor, a 1.5-volt, D-cell battery and a 15-volt battery left over; they will be used if you perform the "Basic Calibration" in the "Calibration" section. The rear panel, faceplate, and thumbnut will be installed in the "Final Assembly" section. Proceed to "Calibration."

¾ ½ ¼ 0 1" 2" 3" 4" 5" 6"

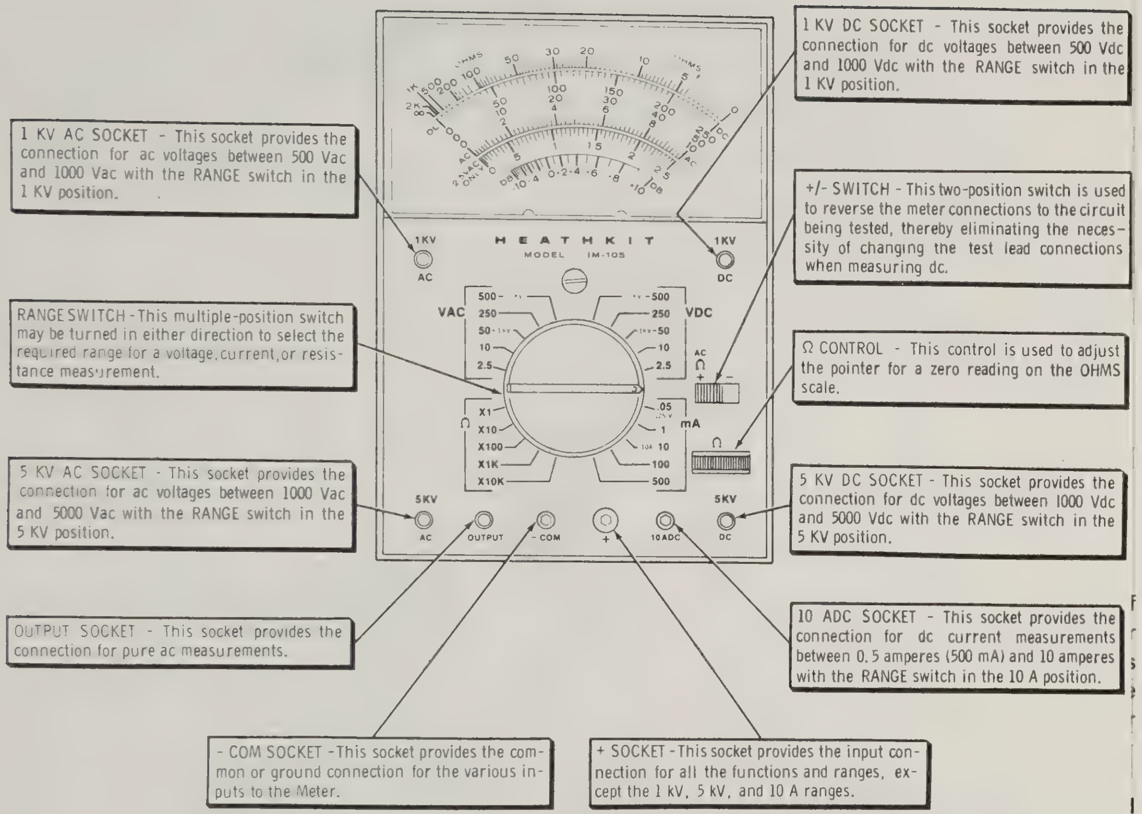


FIGURE 2

CALIBRATION

This section of the Manual contains two calibration procedures. If you have access to a precision standard, proceed with the "Precision Calibration" section on Page 22. If a precision standard is not available, proceed with the following "Basic Calibration" section.

BASIC CALIBRATION

The accuracy of your Meter depends to a great extent upon the care and accuracy that you exercise in performing the following steps. These steps are designed to require only a minimum of equipment to calibrate the ac and dc sections of your Meter. If you do not know how to read the meter scales, the instructions under "Reading the Meter" on Page 24 before proceeding with this Calibration.

If at any time you do not obtain the results called for in a step, refer to the "In Case of Difficulty" section on Page 35 to correct the problem.

Refer to Figure 1 (fold-out from Page 20) for the following steps.

ZERO ADJUST

( ) Check the zero position of the meter pointer. If the pointer does not rest directly over the zero marks at the left end of the meter scales, carefully turn the meter ZERO ADJUST screw at CB to bring the pointer over the zero marks. Tapping the face of the meter is not necessary while positioning the ZERO ADJUST due to the frictionless characteristics of the movement.

DC CALIBRATION

NOTE: The adjustments required in the following steps make it necessary to leave the faceplate off of the meter case. In order to know the locations of the various range-positions and plugs called for in the following steps, temporarily lay the faceplate over the RANGE switch to verify the positions.

( ) Connect the banana plug on the red test lead to the + socket.

( ) Connect the banana plug on the black test lead to the – COM socket.

( ) Turn the RANGE switch to the 1.0 mA position.

( ) Position the +/- switch to the + position.

( ) Attach the alligator clip on the black test lead to one lead of the remaining 1.35 kΩ resistor.

( ) Hold the other lead of the 1.35 kΩ resistor against the negative (-) end of the 1.5-volt, D-cell battery, and hold the tip of the red test probe against the positive (+) end of the battery. Hold these connections together between the thumb and index finger of one hand and read the scale. The pointer should show an approximate full-scale reading. Insert a 1/8" blade screwdriver through the rectangular hole marked "DC CAL" and adjust the control (R32 on the schematic) for a reading of 0.969 mA.

AC CALIBRATION

WARNING: Use extreme care when measuring line voltage to prevent personal shock or instrument damage.

High Range

( ) Turn the RANGE switch to the 250 VAC position.

( ) If the cord for a waffle iron or other household appliance which connects to two round posts on the appliance is available, plug the test probe and the alligator clip into the round connectors on one end of the cord. Plug the other end of the cord into a household line voltage outlet. If no cord is available, attach the alligator clip to a known earth ground and insert the test probe directly into the outlet. If no indication of voltage is obtained on one side of the outlet, try the other side. The pointer should deflect upscale.

NOTE: Successful calibration, in the following step, largely depends upon knowing the value of the line voltage being measured. If the value of line voltage is known, proceed with the following step and adjust the "HI CAL" control to the known value. If the value of line voltage is not known, reasonable accuracy can be obtained by adjusting the "HI CAL" control to its midpoint setting. (Remember that this adjustment can always be "touched-up" when you have access to a known voltage.)

( ) Insert a screwdriver through the hole labeled "HI CAL" and adjust the control (R34 on the schematic) for the line voltage in your area. (In the United States this is usually 120 Vac.)

( ) Disconnect the test leads from the line voltage outlet.

Low Range

( ) Turn the RANGE switch to the 2.5 VAC position.

( ) With one hand, hold the test probe against the positive (+) end of the 1.5-volt, D-cell battery, and hold the alligator clip against the negative (-) end of the battery. The pointer should deflect upscale.

( ) Insert a screwdriver through the hole labeled "LO CAL" and adjust the control (R8 on the schematic) for a reading of 1.72 on the 2.5 VAC scale.

This completes the "Basic Calibration" of your Meter.

PRECISION CALIBRATION

The accuracy of your Meter depends to a great extent upon the care and accuracy that you exercise in performing the following steps. These steps are designed to be used with precision standard equipment to calibrate the ac and dc sections of your Meter. If you do not know how to read the meter scales, read the instructions under "Reading the Meter" on Page 24 before proceeding with this Calibration.

If at anytime you do not obtain the results called for in a step, refer to the "In Case of Difficulty" section on Page 35 to correct the problem.

NOTE: The adjustments required in the following steps make it necessary to leave the faceplate off of the meter case. In order to know the locations of the various range positions and plugs called for in the following steps, temporarily lay the faceplate over the RANGE switch to verify the positions.

Refer to Figure 1 (fold-out from Page 20) for the following steps.

( ) Check the zero position of the meter pointer. If the pointer does not rest directly over the zero marks at the left end of the meter scales, carefully turn the meter ZERO ADJUST screw at CB to bring the pointer over the zero marks. Tapping the face of the meter is not necessary while positioning the ZERO ADJUST due to the frictionless characteristics of the movement.

( ) Turn the RANGE switch to the .05 mA position.

( ) Position the +/- switch to the + position.

( ) Adjust the dc voltage standard for 0.250 volts output.

( ) Connect the voltage standard output to the + and -COM sockets on the Meter.

( ) Insert a 1/8" blade screwdriver through the rectangular hole labeled "DC CAL" and adjust the control (R32 on the schematic) for a full-scale reading on the meter.

( ) Disconnect the leads from the Meter.

( ) Turn the RANGE switch to the 10, 50, or 250 VAC position.

( ) Adjust the ac voltage standard for 10.0, 50.0, or 250.0 volts output as required.

( ) Connect the voltage standard output to the + and -COM sockets on the Meter.

( ) Insert a screwdriver through the hole marked "HI CAL" and adjust the control (R34 on the schematic) for a full-scale reading on the Meter.

( ) Disconnect the leads from the Meter.

( ) Turn the RANGE switch to the 2.5 VAC position.

( ) Adjust the ac voltage standard for 2.50 volts output.

( ) Connect the voltage standard output to the + and -COM sockets on the Meter.

( ) Insert a screwdriver through the hole labeled "LO CAL" and adjust the control (R8 on the schematic) for a full-scale reading on the Meter.

( ) Disconnect the leads from the Meter.

NOTE: If a 10.0 or 50.0 volt standard was used for the adjustment of "HI CAL", some interaction may have occurred between the "HI CAL" and "LO CAL" adjustments. For maximum accuracy these two adjustments should be repeated.

This completes the "Precision Calibration" of your Meter.

FINAL ASSEMBLY

Refer to Pictorial 9 (fold-out from Page 20) for the following steps.

( ) Install the 1.5-volt, D-cell in the center compartment. Be sure to observe the polarity.

( ) Install the 15-volt battery into the right-hand battery compartment. Be sure to observe the polarity.

( ) Slide the rear panel into place on the back of the case. Be sure the panel seats properly in the side slots of the case.

NOTE: The blue and white identification label that is installed in the next step shows the Model number and Production Series number of your kit. Refer to these numbers in any communications with the Heath Company; this assures you that you will receive the most complete and up-to-date information in return.

( ) Carefully peel away the backing paper from the blue and white identification label Then press the label onto the back of the panel.

( ) Insert the thumbnut through the rear panel and tighten it in position.

( ) Lay the Meter backside down on top of your table or workbench.

( ) Lay the faceplate in position on the front of the case with its top edge inserted into the slot in the bottom edge of the meter window. Then, starting at the top of the Range switch cutout, firmly press the faceplate into position all the way around the switch. Finally, press in on the corners to be sure the faceplate is seated in position.

This completes the "Final Assembly."

OHMS ADJUSTMENT

These steps are designed to check and adjust the OHMS scale on your Meter. If at any time you do not obtain the results called for in a step, refer to the "In Case of Difficulty" section on Page 35 to correct the problem.

NOTE: If you do not know how to make a resistance measurement, read the section on "Resistance Measurements" on Page 30 before proceeding with this adjustment. Instructions for reading the OHMS scale are given on Page 25.

( ) Place the +/- switch in the + (Ω) position.

( ) Connect the black lead to the -COM socket.

( ) Connect the red test lead to the + socket.

( ) Place the RANGE switch in the Ω x 10 position. Then, holding the tip of the red test probe and the alligator clip together, adjust the Ω control for a zero reading on the OHMS scale.

( ) Measure the resistance of the 1.35 kΩ calibration resistor.

( ) In a like manner, measure the resistance of the 1.35 kΩ, calibration resistor on the Ω x 100 and the Ω x 1 K ranges. Be sure to readjust the Ω control, if necessary, for each range used.

( ) Place the RANGE switch in the Ω x 10 K position. Then, holding the tip of the red test probe and the alligator clip together, adjust the Ω control for a zero reading on the OHMS scale.

( ) Repeat the above step with the RANGE switch in the Ω x 1 position.

This completes the "Ohms Adjustment." Store the 1.35 kΩ calibration resistor in a safe place for future use. It can be taped inside the top left compartment of the case.

OPERATION

Refer to Figure 2 (fold-out from Page 20) for a description of the control and socket functions.

SAFETY PRECAUTIONS

You may often use your Meter to check, maintain, and repair electronic equipment which contains DANGEROUSLY HIGH VOLTAGES. Because of this danger, you should always observe the safety procedures listed below.

1. Always handle the test probe by the insulated housing only. Be careful not to touch the exposed tip portion.
2. When measuring high voltages, remove the operating power to the equipment to be tested before connecting the test leads. If this is not possible, be very careful to avoid accidental contact with any object that could provide a ground return path.
3. If at all possible, use only one hand when testing energized equipment. Keep one hand in your pocket or behind your back to minimize the possibility of accidental shock.
4. If possible, insulate yourself from ground while making measurements. Stand on a properly insulated floor or floor covering.
5. Before you connect the test leads for a resistance measurement, remove the operating power to the equipment to be tested and discharge any capacitors which may have stored a charge.

READING THE METER

This section of the Manual is designed to familiarize you with the Meter scales. Instructions are given, along with an example, for reading each range on the scale. In addition, the first example for each type of reading is illustrated on the fold-out from Page 27.

Vdc Reading

Proceed as directed to read a voltage on the following ranges.

NOTE: The VDC markings on the RANGE switch refer to the full-scale readings of the Meter.

.25 VDC RANGE — Read the 250 scale and move the decimal three places to the left. For example, a reading of 60 would indicate a measurement of .06 volts as shown in Figure 3 (fold-out from Page 27).

2.5 VDC RANGE — Read the 250 scale and move the decimal two places to the left. For example, a reading of 120 would indicate a measurement of 1.2 volts.

10 VDC RANGE — Read the 10 scale directly. For example, a reading of 8 would indicate a measurement of 8 volts.

50 VDC RANGE — Read the 50 scale directly. For example, a reading of 40 would indicate a measurement of 40 volts.

250 VDC RANGE — Read the 250 scale directly. For example, a reading of 150 would indicate a measurement of 150 volts.

500 VDC RANGE — Read the 50 scale and move the decimal one place to the right. For example, a reading of 40 would indicate 400 volts.

1 KV DC RANGE — Read the 10 scale and move the decimal two places to the right. For example, a reading of 8 would indicate a voltage of 800 volts.

5 KV DC RANGE — Read the 50 scale and move the decimal two places to the right. For example, a reading of 20 would indicate a voltage of 2000 volts.

Vac Readings

NOTE: The VAC markings on the RANGE switch refer to the full-scale readings of the Meter.

To read a voltage on the 2.5 VAC range, read the 2.5 VAC ONLY scale directly. For example, a reading of 2 would indicate a measurement of 2 volts as shown in Figure 4 (fold-out from Page 27).

All ac voltages higher than 2.5 Vac are read on the AC scale and made in the same manner as described for the VDC readings. (Notice that the 250, 50, and 10 scales are common to both the DC and AC scale markings).

Current Readings

Proceed as directed to read current on the following ranges:

NOTE: The mA markings of the RANGE switch refer to the full-scale readings of the Meter. The readings for milliamperes are taken from the DC scales.

.05 MA RANGE — Read the 50 scale and move the decimal three places to the left. For example, a reading of 40 would indicate a measurement of .04 mA as shown in Figure 5 (fold-out from Page 27).

1 MA RANGE — Read the 10 scale and move the decimal one place to the left. For example, a reading of 6 would indicate a measurement of .6 mA.

10 MA RANGE — Read the 10 scale directly. For example, a reading of 8 would indicate a measurement of 8 mA.

100 MA RANGE — Read the 10 scale and move the decimal one place to the right. For example, a reading of 4 would indicate a measurement of 40 mA.

500 MA RANGE — Read the 50 scale and move the decimal one place to the right. For example, a reading of 30 would indicate a measurement of 300 mA.

10 A RANGE — Read the 10 scale directly. For example, a reading of 8 would indicate a measurement of 8 A.

Resistance Readings

Proceed as directed to read resistance on the following ranges:

NOTE: The Ω markings on the RANGE switch are multipliers for the OHMS scale on the Meter.

Ω x 1 RANGE — Read the OHMS scale directly. For example, a reading of 20 would indicate a measurement of 20 Ω as shown in Figure 6 (fold-out from Page 27).

Ω x 10 RANGE — Read the OHMS scale and multiply by 10. For example, a reading of 30 would indicate a measurement of 300 Ω.

Ω x 100 RANGE — Read the OHMS scale and multiply by 100. For example, a reading of 10 would indicate a measurement of 1000 Ω or 1 kΩ.

Ω x 1 K RANGE — Read the OHMS scale and multiply by 1000. For example, a reading of 30 would indicate a measurement of 30,000 Ω, or 30 kΩ.

Ω x 10 K RANGE — Read the OHMS scale and multiply by 10,000. For example, a reading of 20 would indicate a measurement of 200,000 Ω, or 200 kΩ.

DB Readings

Readings on the dB scale are explained under "Decibel Measurements" in this section.

DC Voltage Measurements

The voltage ranges provided by your Meter were selected for easy reading and convenient measuring. The low ranges (.25 to 10) will be very handy for transistor circuits and for bias and filament voltage measurements. The middle ranges (50 and 250) will most often be used when checking ac/dc-type equipment. The high ranges will be used when measuring the higher voltages in transformer-operated equipment. Be sure to take into account the input resistance of the range being used (20,000 Ω x full-scale voltage) in the light of other circuit resistances.

WARNING: Be extremely careful when making measurements of 20 volts or more. If you do not know the value of the voltage, assume that it is dangerous.

To measure dc voltages below 500 Vdc, connect the black test lead between the −COM socket and the common or ground side of the voltage to be measured. Connect the red test lead to the + socket.

If the approximate value of the voltage to be measured is known, set the RANGE switch to the next higher voltage range. If the value of the voltage to be measured is not known, set the RANGE switch to the 500 VDC range. Then, with the red test probe, touch the point in the circuit where the voltage is to be measured. If the indicator moves less than 1/4 of full-scale, switch to the next lower range. If the indicator moves to more than full-scale (pegs), switch to the next higher range. If the indicator deflects to the left, switch the +/-switch for an upscale reading.

The .05 mA range is also the .25 volt range. This range is particularly suited for use as a null detector to measure small differences between two voltage sources.

To measure dc voltages above 500 Vdc, connect the black test lead between the −COM socket and the common or ground side of the voltage to be measured. Connect the red test lead to the 1 KV DC socket for voltage readings from 500 VDC to 1000 VDC. Connect the red test lead to the 5 KV DC socket for voltage readings from 1000 Vdc to 5000 Vdc. These connections to the meter must be made before you attempt to measure the voltage.

Set the RANGE switch to either the 1 or 5 KV DC range (depending on the range of the voltage to be measured); with the equipment turned off, connect the test probe to the point in the circuit where the voltage is to be measured. Then, with one hand behind your back for safety, turn the equipment on. If the Meter reads more than full-scale or deflects to the left, DO NOT touch the Meter, leads, or equipment. Turn the equipment off and, after all capacitors have been discharged, switch the +/- switch to the opposite position or connect the red test lead to the higher range.

AC Voltage Measurements

CAUTION: Be extremely careful when making measurements of 20 volts or more. If you do not know the value of the voltage, assume that it is dangerous.

To measure ac voltages below 500 Vac, connect the black test lead between the −COM socket and the common or ground side of the voltage to be measured. Connect the red test lead to the + socket.

If the approximate value of the voltage to be measured is known, set the RANGE switch to the next higher voltage range. If the value of the voltage to be measured is not known, set the RANGE switch to the 500 VAC range. Then, with the red test probe, touch the point in the circuit where the voltage is to be measured. If the indicator moves less than 1/4 of full-scale, switch to the next lower range. If the indicator moves to more than full-scale (pegs), switch to the next higher range.

To measure ac voltages above 500 Vac, connect the black test lead between the −COM socket and the common or ground side of the voltage to be measured. Connect the the red test lead to the 1 KV AC socket for voltage readings from 500 Vac to 1000 Vac. Connect the red test lead to the 5 KV AC socket for voltage readings from 1000 Vac to 5000 Vac. These connections to the meter must be made before you attempt to measure the voltage.

Set the RANGE switch to either the 1 KV or 5 KV AC range (depending on the range of the voltage to be measured) and, with the equipment turned off, connect the test probe to the point in the circuit where the voltage is to be measured. Then, with one hand behind your back for safety, turn the equipment on. If the Meter reads more than full-scale, DO NOT touch the Meter, leads, or equipment. Turn the equipment off and, after all capacitors have been discharged, connect the red test lead to the higher range.

DB Readings

Readings on the dB scale are explained under "Decibel Measurements" in this section.

DC Voltage Measurements

The voltage ranges provided by your Meter were selected for easy reading and convenient measuring. The low ranges (.25 to 10) will be very handy for transistor circuits and for bias and filament voltage measurements. The middle ranges (50 and 250) will most often be used when checking ac/dc-type equipment. The high ranges will be used when measuring the higher voltages in transformer-operated equipment. Be sure to take into account the input resistance of the range being used (20,000 Ω x full-scale voltage) in the light of other circuit resistances.

WARNING: Be extremely careful when making measurements of 20 volts or more. If you do not know the value of the voltage, assume that it is dangerous.

To measure dc voltages below 500 Vdc, connect the black test lead between the −COM socket and the common or ground side of the voltage to be measured. Connect the red test lead to the + socket.

If the approximate value of the voltage to be measured is known, set the RANGE switch to the next higher voltage range. If the value of the voltage to be measured is not known, set the RANGE switch to the 500 VDC range. Then, with the red test probe, touch the point in the circuit where the voltage is to be measured. If the indicator moves less than 1/4 of full-scale, switch to the next lower range. If the indicator moves to more than full-scale (pegs), switch to the next higher range. If the indicator deflects to the left, switch the +/-switch for an upscale reading.

The .05 mA range is also the .25 volt range. This range is particularly suited for use as a null detector to measure small differences between two voltage sources.

To measure dc voltages above 500 Vdc, connect the black test lead between the −COM socket and the common or ground side of the voltage to be measured. Connect the red test lead to the 1 KV DC socket for voltage readings from 500 VDC to 1000 VDC. Connect the red test lead to the 5 KV DC socket for voltage readings from 1000 Vdc to 5000 Vdc. These connections to the meter <u>must</u> be made before you attempt to measure the voltage.

Set the RANGE switch to either the 1 or 5 KV DC range (depending on the range of the voltage to be measured); with the equipment turned off, connect the test probe to the point in the circuit where the voltage is to be measured. Then, with one hand behind your back for safety, turn the equipment on. If the Meter reads more than full-scale or deflects to the left, DO NOT touch the Meter, leads, or equipment. Turn the equipment off and, after all capacitors have been discharged, switch the +/- switch to the opposite position or connect the red test lead to the higher range.

AC Voltage Measurements

CAUTION: Be extremely careful when making measurements of 20 volts or more. If you do not know the value of the voltage, assume that it is dangerous.

To measure ac voltages below 500 Vac, connect the black test lead between the −COM socket and the common or ground side of the voltage to be measured. Connect the red test lead to the + socket.

If the approximate value of the voltage to be measured is known, set the RANGE switch to the next higher voltage range. If the value of the voltage to be measured is not known, set the RANGE switch to the 500 VAC range. Then, with the red test probe, touch the point in the circuit where the voltage is to be measured. If the indicator moves less than 1/4 of full-scale, switch to the next lower range. If the indicator moves to more than full-scale (pegs), switch to the next higher range.

To measure ac voltages above 500 Vac, connect the black test lead between the −COM socket and the common or ground side of the voltage to be measured. Connect the the red test lead to the 1 KV AC socket for voltage readings from 500 Vac to 1000 Vac. Connect the red test lead to the 5 KV AC socket for voltage readings from 1000 Vac to 5000 Vac. These connections to the meter <u>must</u> be made before you attempt to measure the voltage.

Set the RANGE switch to either the 1 KV or 5 KV AC range (depending on the range of the voltage to be measured) and, with the equipment turned off, connect the test probe to the point in the circuit where the voltage is to be measured. Then, with one hand behind your back for safety, turn the equipment on. If the Meter reads more than full-scale, DO NOT touch the Meter, leads, or equipment. Turn the equipment off and, after all capacitors have been discharged, connect the red test lead to the higher range.

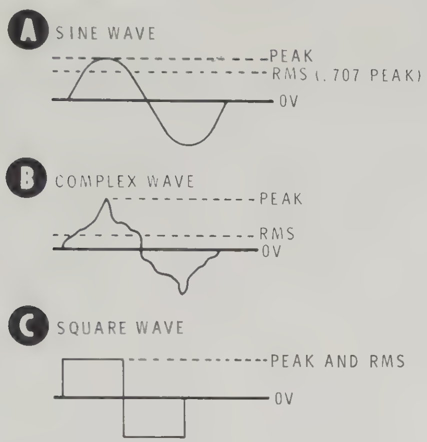


Figure 7

AC Voltage Interpretation

Your Meter can measure almost any type of ac voltage. Filament voltage, power line voltage, noise voltage, or even output or gain measurements can be made quickly and accurately. It is important, however, to understand how the various types of input waveforms affect the readings and how to interpret these readings for the greatest accuracy. For this reason, the following information is presented.

When a dc voltage is applied to a resistor, it produces a measurable temperature increase in the resistor. If an ac voltage is applied to the same resistor and produces the same temperature increase, then the ac voltage must be producing the same amount of power. Since this power produced by the ac voltage is averaged over a period of time, it is called mean (or average) power. The ac voltage that produces this power is proportional to the square root of the mean power and is called the root-mean-square or rms voltage. AC meters are usually calibrated in rms voltage. For a sine wave (see Figure 7A), which is the most common ac voltage waveform, the rms value of each half cycle is .707 times the peak of the waveform.

If the input voltage to your Meter is an ac sine wave, both the positive and negative portions of the signal will deflect the indicator upscale.* Since the meter movement has mechanical inertia, it "averages" the current pulses and causes the indicator to show this average value. Therefore, the scales are designed to indicate the rms value of a sine wave while the Meter itself is actually responding to the average value of both the positive and negative portions of the waveform.

If a non-sinusoidal waveform such as a square-wave, sawtooth wave, or pulse is being measured, the indicated reading on the scale must be given some special interpretation. For example, the complex waveform shown in Figure 7B contains a "spike" (peak) that may be several times as large as the average value of the waveform. Since the spike is of such short duration, the average value of the overall waveform is barely affected. On the other hand, the symmetrical square wave (i.e. a square wave having positive and negative portions of equal amplitude and time duration) shown in Figure 7C would indicate an rms value higher than its peak value. On your Meter, a symmetrical square wave having a 1.0 volt peak would indicate 1.11 volts.

It is important to remember that if the waveform is known to be non-sinusoidal, it should be examined with an oscilloscope or a true rms meter if highly accurate measurements are desired.

Meter Loading

When you connect your Meter to a circuit to make measurements, the input resistance and the input capacitance of the Meter are, in effect, placed in parallel with those parts of the circuit located between the test leads. In some cases this can load the circuit under test and change the actual value of the voltage being measured.

The amount of loading presented by the input resistance is primarily determined by the impedance of the circuit under test. In low source impedance circuits, up to 600 Ω, no noticable error is introduced through loading.

The amount of loading presented by the input capacitance is primarily determined by the frequency of the signal under test. In low frequency circuits the effects of capacitive loading may usually be disregarded. In high frequency circuits, however, the effects of capacitive loading may considerably alter the voltage at the point of measurement.

*See the "AC Voltage Measurement" portion of the "Circuit Description" section.

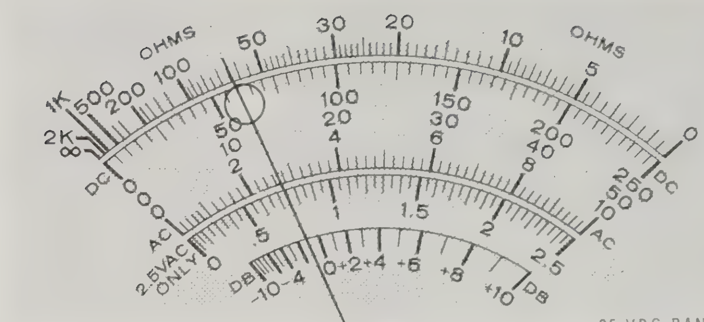


FIGURE 3

.25 VDC RANGE MEASURING
.06 Vdc

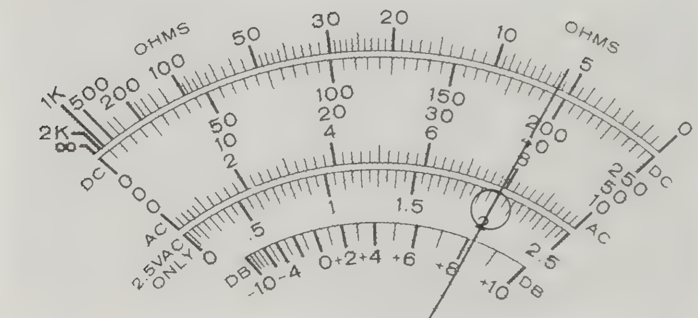


FIGURE 4

2.5 VAC RANGE MEASURING
2.0 Vac

FIGURE 5

.05 MA RANGE MEASURING
.04mA

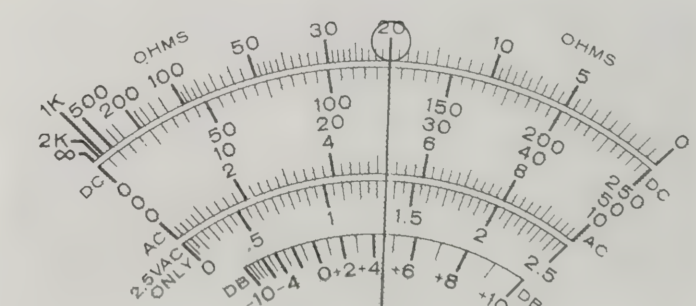


FIGURE 6

Ωx1 RANGE MEASURING
20Ω

Pure ac Measurements

WARNING: When making ac measurements in circuits having a dc voltage in excess of 200 Vdc, DO NOT attempt to measure any point where the instantaneous voltage (peak ac + dc) may exceed 400 volts.

Your Meter will indicate the presence of dc voltages on the ac voltage ranges. If you wish to measure only the ac component, connect the red test lead to the OUTPUT socket of the Meter. This socket feeds the incoming signal through an internal .22 μF capacitor that effectively blocks the dc component. When using the OUTPUT socket with a low frequency input on the 2.5 VAC or 10 VAC ranges, the indicated voltage reading will be something less than the actual voltage value. This is due to the increased impedance of the .22 μF capacitor on these ranges at low frequencies. On higher ranges, or at higher frequencies, this effect becomes negligible.

If you desire to make a low range voltage measurement at a low frequency, connect the red test lead to the + socket and place a large value, non-polarized capacitor, having a sufficient dc voltage rating, in series with the red test probe and the point of measurement. The value of this capacitor, usually between 1 μF and 100 μF, depends on the frequency of the signal and the accuracy required in the reading.

Decibel Measurements

Because the human ear does not respond to sound volume in direct proportion to sound intensity, the telephone industry adopted a logarithm-based system of measurement which more nearly matches the human hearing response. The basic unit of measurement in this system is called the "bel". The bel is mathematically expressed as:

$$\text{bel} = \log \frac{P_1}{P_2}$$

where P_1 and P_2 refer to two sound intensity levels.

Since differences as small as 0.1 to 0.3 bels are detectable by human hearing, a smaller increment of the bel, called the decibel, is more convenient to use. A decibel (dB) is 1/10 of a bel, and is mathematically expressed as:

$$\text{dB} = 10 \log \frac{P_1}{P_2}$$

where the 10 appears because a decibel is 1/10 of a bel.

The decibel system was adapted to electrical measurements in order to describe power ratios. When used in this manner, P_1 could refer to the output power and P_2 could refer to the input power of an amplifier.

Decibels can also be used to express voltage ratios; however, extreme care must be taken to insure that the conversion to these ratios is accurate. The basis for the use of decibels to express voltage ratios is given in the following discussion.

Electrical power is mathematically expressed as:

$$P = \frac{E^2}{R}$$

where E refers to the circuit voltage and R refers to the circuit resistance. Therefore, decibels can be expressed for two power levels as:

$$\text{dB} = 10 \log \left(\frac{E_1{}^2/R_1}{E_2{}^2/R_2} \right)$$

Then, if R_1 and R_2 are equal in value:

$$\text{dB} = 10 \log \left(\frac{E_1{}^2}{E_2{}^2} \right)$$

$$= 20 \log \left(\frac{E_1}{E_2} \right)$$

This last example is perhaps the most common form of the equation; however, it must be clearly understood that the equation is valid <u>only</u> because of the assumption that R_1 and R_2 are equal.

Values used to express measurements of electrical gain or electrical attenuation often lead to the use of some rather unwieldy numbers without the use of dB's. As an example, consider two amplifiers having voltage gains of 100 and 1000. If these two amplifiers are connected in series, their total gain would be 100 x 1000 or 100,000. Using dB's the individual gains would be 40 dB and 60 dB. The total voltage gain would be expressed as 100 dB. Thus, the addition of dB numbers is equivalent to the multiplication of conventional numbers. Also, the subtraction of dB numbers is equivalent to the division of conventional numbers. As you can see, these properties make decibel units very convenient.

Several systems exist for defining a dB reference level that can be compared to other power levels. One of the more common power levels used as a reference is 1 milliwatt. If this reference is used, then decibels may be expressed in the unit "dBm, where the m refers to 1 milliwatt.

In audio systems, where the circuit impedance level is usually 600 Ω's, a power level of 1 milliwatt into 600 Ω's is produced by 0.775 volts rms. This is the point on the Meter's dB scale (on the 2.5 VAC range) that corresponds to "0 dB". When comparing dB readings on different ac ranges of the Meter, use the range factors listed on the scale starting from the 2.5 VAC range.

The use of decibels to express measured voltage ratios in other than 600 Ω systems is valid only if the impedance levels are equal. If the impedance levels are not equal, it is necessary to convert the readings to a power level where a valid comparison can be made. A comparative measurement of two voltage levels at the same circuit location, however, is valid since the impedance level would be the same.

One example of the use of your Meter's dB scales would be to check the flatness of the frequency response of an audio amplifier. Use the following procedure to make this check.

NOTE: Use a low impedance, variable frequency, sine-wave signal generator in the following steps. Set the output voltage to 1.0 volt rms or higher.

1. Connect the signal generator to the input of the amplifier. If the amplifier requires a lower input level for undistorted operation, use an impedance-matching attenuator.

2. Set the signal generator frequency to the lowest frequency of interest.

3. Connect your Meter (in the same manner as for any ac voltage measurement) and the proper resistive load to the output of the amplifier.

4. Readjust the signal generator's output level to obtain the desired output voltage or power level from the amplifier. If an exact output level is not required, the signal generator may be adjusted to indicate a specific point on the Meter's dB scale: such as 0 dB, -6 dB, or +2 dB.

5. Note the indication on the Meter.

6. Connect the Meter to the output of the signal generator and note the voltage.

7. Set the signal generator frequency to the next highest value of interest and, if necessary, readjust the output level to that of the previous measurement.

8. Reconnect the Meter to the amplifier's output and note the dB reading.

Repeat steps six, seven, and eight at as many frequency points as desired. Then use the recorded dB readings to express the flatness of the amplifer's response over a prescribed bandwidth.

The dB scale can also be used to:

- Examine gain versus control voltage in avc (automatic volume control) circuits.
- Measure the signal reduction in T-pad, L-pad, or other attenuator circuits.
- Measure the effect of bass or treble controls in audio circuits versus the frequency or setting.
- Examine pass-band, stop-band, and attenuation of filter networks.
- Verify the flatness of response of signal generators.

It is certainly unlikely that these explanations have adequately covered such a complex subject as the use of decibels. There are, however, many fine textbooks that treat the subject in greater detail.

Resistance Measurements

WARNING: Before you connect the meter leads to make a resistance measurement, remove the operating power to the equipment to be tested and discharge any capacitors which may have stored a charge.

To measure resistance with your Meter, connect the black lead to the −COM socket and the red test lead to the + socket. If the approximate value of the resistance is known, set the RANGE switch to the range that will indicate as near a midscale reading as possible. Then touch the test probe tip and the alligator clip together and adjust the thumbwheel control marked "Ω" for a zero reading on the OHMS scale. NOTE: If the Ω x 1 range is to be used, make this adjustment on the Ω x 10 range. Then switch back to the Ω x 1 range and, with the leads still touching, note the reading on the scale. This reading reflects the resistance of the two leads and should be subtracted from any subsequent readings taken on the Ω x 1 range.

With the Meter properly zero adjusted, connect the black lead to one side of the resistance to be measured. Then, while touching the other side with the red test probe, read the resistance on the OHMS scale. Be sure to multiply the reading by the proper factor as shown by the RANGE switch.

When resistance measurements are not being made, avoid the possibility of battery drain by placing the RANGE switch in one of the volts positions.

CAUTION: Your Meter can be used to check the forward and reverse resistance of diodes and transistors, but use the Ω x 10, Ω x 100, or Ω x 1 k ranges only. The Ω x 1 range may cause excessive forward conduction while the Ω x 10 k range may cause a junction breakdown.

Current Measurements

CAUTION: All dc current measurements must be made by connecting the Meter leads in series with the current to be measured. Be sure that the circuit is turned off prior to connecting the leads.

To measure a dc current of 500 mA or less, connect the black test lead between the −COM socket and the negative side of the circuit to be measured. Connect the red test lead between the + socket and the positive side of the circuit to be measured.

If the approximate value of the current to be measured is known, set the RANGE switch to the next higher current range. If the value of the current to be measured is not known, set the RANGE switch to the 500 mA range. Turn the circuit on. If the indicator moves to the left, change the position of the +/− switch. If the indicator moves less than 1/4 of full-scale, switch to the next lower range. If the indicator moves to more than full-scale (pegs), switch to the next higher range. If the measurement can be made on more than one range, the measured current will more accurately indicate the actual current on the higher range.

To measure a dc current above 500 mA, connect the black test lead between the −COM socket and the negative side of the circuit to be measured. Connect the red test lead between the 10 ADC socket and the positive side of the circuit to be measured. Set the RANGE switch in the 10 A position. Then, turn the circuit on and read the scale. If necessary, change the position of the +/−switch.

Meter Accuracy

The meter movement is accurate to within ±2% of full-scale. When measuring dc, the ±1% accuracy of the divider resistors must also be considered, resulting in an accuracy within ±3% of full-scale. When measuring ac, the rectifier circuit contributes variations which result in an accuracy of ±4% of full-scale.

The accuracy on the OHMS ranges depend primarily on the ±1% accuracy of the multipliers and the ±2% accuracy of the meter. The resulting accuracy is not readily expressed as a percentage figure because of the nonlinear OHMS scale.

NOTE: When comparing the IM-105 with another meter, consider that the error of the other meter may be in the opposite direction. For example, when comparing two meters having an accuracy of ±5%, the total difference may be as much as ±10%. Critical comparisons should only be made against certified standards.

MAINTENANCE

This section of the Manual will provide you with the information necessary to keep your Meter in peak operating condition. As with any precision instrument, periodic inspections and prompt attention to small problems will often forestall more troublesome difficulties.

TEST LEADS

Because of their constant flexing during use, the test leads should never be above suspicion when difficulties occur. Bad test leads not only cause the meter to stop functioning or respond in an erratic manner, but are potentially dangerous. If there is ever any doubt, it is best to obtain new test lead wires.

BATTERY CHAMBERS

Periodic inspection of the battery chambers inside the case may avoid a difficult clean-up problem because of leaking batteries. After carefully removing the battery contact clips, the battery chambers may be cleaned with a damp cloth. Avoid getting any other areas of the case wet, and allow the chambers to thoroughly dry before replacing the batteries. The contact clips should be free of oxidation and tarnish. A few strokes with a fine grade of sandpaper will usually restore the clips.

ELECTROSTATIC CHARGE

The clear plastic meter window has been treated to resist the accumulation of a static charge. However, should a static charge accumulate through repeated rubbing of the meter window, the pointer will deflect in an erratic manner on all range settings. This condition can be easily corrected by applying a <u>small</u> quantity of liquid dishwashing detergent to a soft cloth and wiping the surface of the meter window. DO NOT remove the meter window for this operation.

METER MOVEMENT

Because of the delicate nature of the meter movement, you should never attempt to repair the meter. Any such attempt will automatically void the standard warranty coverage of the Meter.

METER COIL

If you suspect that the meter coil has failed, you can check the continuity of the coil with another ohmmeter as follows: <u>Never</u> check the continuity of the meter coil <u>directly</u> with another ohmmeter. The amount of current that would be drawn would seriously overload and probably ruin the coil. Always use a limiting resistor having a value of at least 50,000 Ω in series with the other ohmmeter's test lead. The actual value of the resistor will depend upon the other ohmmeter's battery voltage and the setting of its range switch.

FUSE

The fuse may be replaced with a new one ordered from the Heath Company (see the "Parts List"), or with any 2-ampere, 8AG, instrument type fuse.

METER WINDOW REPLACEMENT

In the event that the meter window should ever be cracked or broken, it may be replaced as follows:

NOTE: Since the mechanism of the meter is delicate and sensitive to the environment, the following steps should only be performed in a dust-free room and on a firm table.

( ) Remove the faceplate. Insert the flat of a small screwdriver through one of the 5 KV input holes and lift the faceplate up. Continue to lift until the faceplate snaps out. Then set the faceplate aside with its face down.

( ) Remove the two screws which hold the window in place.

( ) Carefully lift the bottom of the old window up and off of the case. Do not contact the pointer in any way.

( ) Examine the inside of the old window and observe the position of the small crank attached to the meter zero adjustment screw.

( ) Turn the zero adjustment screw to adjust the position of the crank in your new window. The position of the new crank must exactly match the position of the old crank.

( ) Insert the top edge of the new window into the case. Be sure that the rectangular areas on the top edge of the window seat into the openings inside the edge of the case. Carefully ease the window down while observing that the crank stays in alignment with its corresponding slot and that the pointer stays in between the two ceramic stops attached to the window. Then, if everything appears to be in order, press the window into position.

( ) Use a screwdriver to turn the ZERO ADJUST screw. Be sure that the indicator can be adjusted above and below the zero mark. Then adjust the pointer directly over the zero mark.

( ) Replace the window retaining screws, but do not overtighten them.

( ) Lay the faceplate in position on the front of the case with its top edge inserted into the slot in the bottom edge of the meter window. Then, starting at the top of the Range switch cutout, firmly press the faceplate into position all the way around the switch. Finally, press in on the corners to be sure the faceplate is seated in position.

CASE AND METER REPLACEMENT

In the event the meter mechanism is damaged due to mechanical impact or severe electrical overload, the entire case and meter assembly must be replaced. The following procedure should be followed to replace the case and meter assembly.

NOTE: Because of the delicate nature of the meter movement, you should never attempt to repair the meter. Any such attempt will automatically void the standard warranty coverage of the meter.

( ) Turn the Range switch to the 500 VAC position for use as a reference.

( ) Remove the thumbnut and rear panel.

( ) Remove the faceplate. Insert the flat of a small screwdriver through one of the high voltage input holes and lift the faceplate up. Continue to lift until the faceplate snaps out. Then set the faceplate aside with its face down.

( ) Use the tool end of the thumbnut to remove the 10 ADC, +, and −COM sockets.

( ) Remove both batteries.

( ) Carefully disengage the battery clips at each end of both battery chambers.

NOTE: You can try to remove the two battery cushions and the two battery polarity labels for use in your new case. However, due to aging, these items are often difficult to remove without tearing. If necessary, refer to the "Parts List" and order replacements.

( ) Remove the calibrating resistor from the top left compartment if it has been stored there.

( ) Remove the handle.

( ) Remove the two hexagon-head screws that hold the circuit boards to the case.

( ) Place one hand over the back of the case to catch the circuit boards as you shake them from the case with the other hand.

( ) Remove the dust cover.

( ) Remove the shaft from the Range switch.

( ) Carefully examine and memorize the fit of the Range switch on the inside of the case. Notice that the thin white edge on the back of the knob is flush with the inside of the case.

CAUTION: Perform the next step on top of a large table since several small parts may be released and lost if care is not taken.

( ) Position the case face down on a table. Prop up one side of the case with you fingers. Then press on the Range switch knob from inside the case until it snaps out of its opening.

( ) STOP IMMEDIATELY and locate the two detent rollers and two detent springs (shown in Figure 8C). Look on the rear of the knob and on the front of the case. If all four parts (two rollers and two flat springs) are not found, you will be unable to continue with the case replacement.

( ) Take the new case and meter assembly and place it face up on the table.

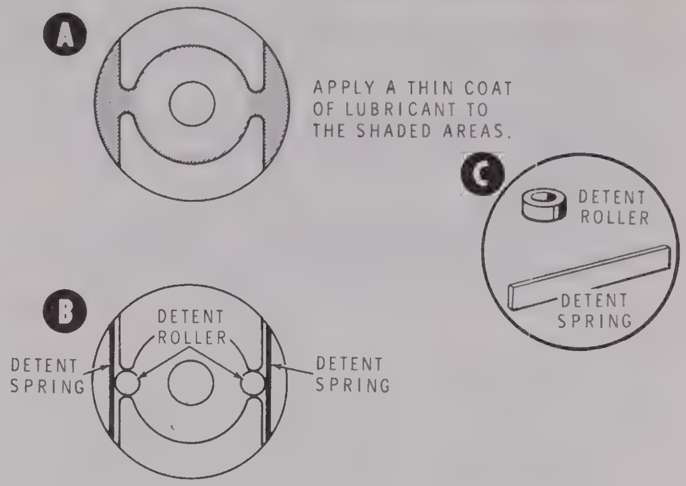


Figure 8

( ) Refer to Figure 8A and apply a thin coat of lubricant (Lubriplate or Vaseline) into the umbrella-shaped areas on both sides of the Range switch knob depression. Use a match or toothpick to apply the lubricant. Do not use a cottom-tipped swab as the fibers that come loose may cause binding in the detent mechanism.

( ) Also apply a thin coat of lubricant on the inside edge of the hole and on the inside edge of the side walls of the Range switch knob depression. Wipe off any excess lubricant that may be on the front of the case.

( ) Carefully clean and relubricate the two springs and two rollers removed from the old assembly.

( ) Refer to Figure 8B and place the two springs and then the two rollers as shown.

( ) Position the knob and, with a steady downward pressure, rotate it until you feel both detent rollers move back against the springs and allow the knob to seat. Still holding the knob firmly, turn the case over and determine that the edge of the knob is as flush with the inside of the case as before. If not, continue to press and rotate the knob until it is.

( ) Rotate the knob one complete turn to insure that it detents properly.

( ) Turn the Range switch to the 500 VAC reference position.

( ) Install the shaft into the back of the Range switch knob. Be sure to hold the knob against the case to prevent it from being pushed out.

( ) Install the dust cover.

( ) Install the two circuit boards. Be sure that the battery clip wires do not interfere with any of the controls or access to the hex head screw holes. Rotate the Range switch knob until its shaft goes through the rotor wafers on both circuit boards.

( ) Install the two hex head screws.

( ) Install the battery cushions in the battery chamber.

( ) Install the battery polarity labels.

( ) Install the battery clips.

( ) Install the handle.

( ) Tape the calibrating resistor into the top left compartment if it was stored there.

( ) Use the tool end of the thumbnut and install the 10 ADC, +, and -COM sockets.

( ) Install the rear panel and thumbnut.

NOTE: Your meter circuits should be recalibrated for optimum performance with the new meter movement. If calibration is to be performed at this time, proceed to the "Calibration" section on Page 21. If calibration is to be performed later, proceed with the following step.

( ) Lay the faceplate in position on the front of the case with its top edge inserted into the slot in the bottom edge of the meter window. Then, starting at the top of the Range switch cutout, firmly press the faceplate into position all the way around the switch. Finally, press in on the corners to be sure the faceplate is seated in position.

IN CASE OF DIFFICULTY

This section of the Manual is divided into two parts. The first part, titled "General Troubleshooting Information," describes what to do about the difficulties that may occur right after your Meter is assembled.

The second part, titled "Troubleshooting Chart," is provided to assist you in servicing the Meter if the General Troubleshooting Information fails to clear up the problem, or if difficulties occur after your Meter has been in use for some time. The "Troubleshooting Chart" lists a number of possible difficulties that could arise along with several possible solutions to those difficulties.

Before starting any troubleshooting procedure, try to narrow the problem down to a specific area by trying the various functions of your meter.

GENERAL TROUBLESHOOTING INFORMATION

The following paragraphs deal with the types of difficulties that may show up right after your kit is assembled. These difficulties are most likely the result of assembly errors or faulty soldering. These checks will help you locate any error of this type that might have been made.

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the "Kit Builders Guide" and to the "Factory Repair Service" information on Page 38 of this Manual.

1. Recheck the wiring. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently over-looked by the builder.

2. About 90% of the kits that are returned for repair do not function properly due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure that they are soldered as described in the soldering section of the "Kit Builders Guide."

3. Check the values of the parts. Be sure that the proper part has been wired into the circuit, as shown in the Pictorials and as called out in the step-by-step instructions. Pay special attention to resistor values, since there are many resistors of similar value that are easily interchanged.

4. Check for bits of solder, wire ends or other foreign matter which may be lodged in the wiring or between parts.

5. Check for solder bridges between circuit board foils.

6. Check the batteries. Be sure that they are fresh and making good electrical contact with their terminal connections.

7. There is a chance that a resistor may have been damaged during soldering. If another ohmmeter is available, check each individual resistor. Each resistor should read very close to its marked value. These checks can be aided by consulting the "Circuit Board X-Ray Views" section of the Manual on Page 46. Be sure to remove one of the hexagon-head screws before making any resistance checks. The circuit board assembly will have to be removed from the case to make measurements on the front circuit board.

8. A review of the "Circuit Description" section on Page 42 and a study of the Schematic (fold-out from Page 47) may also help you locate a difficulty in your Meter.

Troubleshooting Chart

SYMPTOM	POSSIBLE CAUSE
Inoperative on all ranges.	1. Test lead open. 2. Fuse blown. 3. Hexagon-head screws not tight. 4. S1, S2, or S3 defective. 5. D3 or D4 shorted. 6. R32, R33, or RT1 open. 7. Defective connection at Molex connector C. 8. Spring is out of fuseholder. 9. Shorting clip not removed between meter posts. 10. Meter coil open.
Inoperative on dc voltage ranges only.	1. One or more open in the R21 through R27 string of resistors (see Schematic). 2. S1 or S2 defective. 3. Defective connection at Molex connector A.
Inoperative on ac voltage ranges only.	1. One or more open in the R1 through R8 string of resistors (see Schematic). 2. D1 and D2 shorted. 3. D1 and D2 open. 4. R19 and R20 open. 5. C2 shorted. 6. S1 or S2 defective. 7. Defective connection at Molex connector E, G, or F.
Inoperative for ac input between OUTPUT and -COM sockets.	1. C1 open.
Inoperative on ohms ranges only.	1. Battery E1 or E2 either weak or dead. 2. Battery E1 or E2 making a poor connection. 3. Open wire to E1 or E2. 4. S1 or S2 defective. 5. One or more open in resistors R9 through R16. 6. R35 or R36 defective. 7. Defective connection at Molex connector D.
Inoperative on mA ranges only.	1. Defective connection at Molex connector B. 2. S1 or S2 defective. 3. R17, R18, R28, R29, or R30 defective.
Inaccurate dc voltage readings.	1. "DC CAL" control R32 misadjusted or defective. 2. Defective or wrong value in the R21 through R27 string of resistors (see Schematic). 3. D3 or D4 leaky. 4. S1 defective.

SYMPTOM	POSSIBLE CAUSE
Inaccurate ac voltage readings.	1. DC voltage is present in conjunction with ac voltage (see the ac voltage measurement section under "Operation"). 2. "LO CAL" or "HI CAL" controls misadjusted or defective. 3. Defective or wrong value in the R1 through R8 string of resistors. 4. D1 or D2 open, shorted, or leaky. 5. D3 or D4 shorted or leaky. 6. Defective or wrong value for R19, R20, R34, or R40. 7. C2 leaky. 8. S1 defective.
Meter reads negative for ac voltage readings.	1. D1 or D2 installed backwards. 2. Presence of negative dc voltage in conjunction with ac voltage (see ac voltage measurement section under "Operation"). 3. +/- switch in - position.
Inaccurate ohms readings.	1. Defective or wrong value in the R9 through R16 circuit. 2. Batteries E1 or E2 weak. 3. Defective connection at Molex connector D. 4. S1 defective.
Inaccurate mA readings.	1. "DC CAL" control R32 misadjusted. 2. Defective or wrong value in R17, R18, R28, R29, or R30. 3. S1 defective.
Ohmmeter will not zero on high ohms ranges.	1. Batteries E1 or E2 weak. 2. Defective or wrong value for R35. 3. R36 defective. 4. +/- switch in - position.
Ohmmeter will not zero on R x 1 ohms range.	1. Battery E1 weak. 2. Defective or wrong value for R9. 3. If the ohmmeter reads less than 0.2 Ω after zeroing on the higher ranges, this is the normal test lead resistance. If the ohmmeter reads more than 0.2 Ω, the test leads may be defective. 4. +/- switch in - position.

FACTORY REPAIR SERVICE

You can return your completed kit to the Heath Company Service Department to have it repaired for a minimum service fee. (Kits that have been modified will not be accepted for repair.) Or, if you wish, you can deliver your kit to a nearby Heathkit Electronic Center. These centers are listed in your Heathkit catalog.

To be eligible for replacement parts under the terms of the warranty, equipment returned for factory repair service, or delivered to a Heathkit Electronic Center, must be accompanied by the invoice or the sales slip, or a copy of either. If you send the original invoice or sales slip, it will be returned to you.

If it is not convenient to deliver your kit to a Heathkit Electronic Center, please ship it to the factory at Benton Harbor, Michigan and observe the following shipping instructions:

Prepare a letter in duplicate, containing the following information:

- Your name and return address.
- Date of purchase.
- A brief description of the difficulty.
- The invoice or sales slip, or a copy of either.
- Your authorization to ship the repaired unit back to you C.O.D. for the service and shipping charges, plus the cost of parts not covered by the warranty.

Attach the envelope containing one copy of this letter directly to the unit before packaging, so that we do not overlook this important information. Send the second copy of the letter by separate mail to Heath Company, Attention: Service Department, Benton Harbor, Michigan 49022.

Check the equipment to see that all parts and screws are in place. Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least THREE INCHES of resilient packing material (shredded paper, excelsior, etc.) on all sides, between the equipment and the carton. Seal the carton with gummed paper tape, and tie it with a strong cord. Ship it by prepaid express, United Parcel Service, or insured parcel post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

SPECIFICATIONS

DC VOLTMETER

Six Switch-Selected Ranges	0-.25, 2.5, 10, 50, 250, and 500 volts full-scale.
Two Separate Input Ranges	
Range Switch in 50-volt Position	0-1000 volts full-scale.
Range Switch in 500-volt Position	0-5000 volts full-scale.
Input Resistance	20,000 ohms per volt.
Accuracy	±3% of full-scale. (calibrated to standards)

DC MICROAMMETER

One Switch-Selected Range	0-50 microamperes full-scale.
Voltage Drop	0.25 volt at full-scale.
Insertion Resistance	5.0 kΩ.
Accuracy	±2% of full-scale.

DC MILLIAMMETER

Four Switch-Selected Ranges	0-1.0, 10, 100, 500 milliamperes full-scale.
Voltage Drop	Full-scale current multiplied by the insertion resistance.
Insertion Resistance (approximate)	250 Ω on the 1.0 mA range. 26.2 Ω on the 10 mA range. 2.63 Ω on the 100 mA range. 0.526 Ω on the 500 mA range.
Accuracy	±3% of full-scale.

DC AMMETER

One Separate Input Range (Range switch in 10 mA position)	0-10 amperes full-scale.
Voltage Drop (approximate at full-scale)	0.270 volt.
Insertion Resistance	0.027 Ω
Accuracy	±3% of full-scale.

AC VOLTMETER

Five Switch-Selected Ranges	0-2.5, 10, 50, 250, and 500 volts full-scale.
Two Separate Input Ranges	
Range Switch in 50-volt Position	0-1000 volts full-scale.
Range Switch in 500-volt Position	0-5000 volts full-scale.
Input Resistance	5,000 ohms per volt.
Input Capacitance	Less than 20 pF.
Accuracy	±4% of full-scale.
Frequency Response	
(from low impedance source)	±5%.
Maximum dc + ac voltage	400 volts.
(Input between + and - COM sockets)	10 Hz to 100 kHz on 2.5, 10, and 50-volt ranges. 10 Hz to 50 kHz on 250 and 500-volt ranges.
(Input between Output and -COM sockets)	200 Hz to 100 kHz on 2.5 volt range. 100 Hz to 100 kHz on 10-volt range. 20 Hz to 100 kHz on 50-volt range. 10 Hz to 50 kHz on 250 and 500-volt ranges.

OHMMETER

Five Ranges	RX1 (approximately 20 Ω center scale), RX10, RX100, RX1k, RX10k.
Accuracy	±3 degrees of arc.
Source Voltage	1.5 volts (RX1, RX10, RX100, RX1k). 15 volts (RX10k).

DB RANGES

Five Ranges (0 dB = 1 mW into 600 Ω)	-10 to +10 on 2.5-volt range. +2 to +22 on 10-volt range. (Add 12 dB to reading.) +16 to +36 on 50-volt range. (Add 26 to dB to reading.) +30 to +50 on 250-volt range. (Add 40 dB to reading.) +36 to +56 on 500-volt range. (Add 46 dB to reading.)

Accuracy	±1.5 dB at -10 dB to ±0.5 dB at +10 dB.

GENERAL

Voltage Dividers	1% precision resistors.
Meter	4-1/2", 50 μA, 95 degree taut band, movement.
Meter Protection	2-ampere, quick-blow, input fuse on all ranges except 1000 and 5000 volts AC and DC and 10 Ampere range. Two reverse-parallel diodes across meter coil for short term overloads of 100 times and long term overloads of 20 times.
Meter Temperature Coefficient	Maximum of ±0.1% or 0.1 degree of arc (whichever applies) per degree C over the range of 15 to 35 degree C.
Operating Temperature	0 to 55 degree C.
Storage Temperature (less batteries)	-40 to +80 degree C.
Batteries Required	1.5-volt, D-cell (NEDA #14). 15-volt (NEDA #208).
Dimensions	4.95" wide x 6.95" high x 2.25" deep.
Weight (with batteries installed)	2 pounds (approximately).

The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (fold-out from Page 47) while you read this "Circuit Description."

NOTE: The term "meter circuit" used in the following discussion, refers to the combined resistances of the meter coil, thermistor RT1, "DC CAL" R32, and resistor R33.

VDC MEASURING CIRCUIT

A simplified schematic of the dc voltmeter circuit is shown in Figure 9. Since the meter movement has a full-scale deflection sensitivity of 50 μA, a voltage divider (R21, R22, R23, R24, R25, R26, and R27) is connected in series with the meter and the external voltage to limit the current properly for each voltage range.

The total resistance of the voltage divider and the meter circuit is 100 MΩ. Therefore if 5000 volts is applied to the 5KV DC socket, only 50 μA will flow through the circuit. This can be proven mathematically by using Ohm's law:

$$I = \frac{E}{R}$$

where E = 5000 volts and R = 100,000,000 Ω

$$\text{then } I = \frac{5000}{100{,}000{,}000} = .00005 \text{ or } 50\ \mu A$$

Since the 1KV DC socket is connected to a lower resistance tap on the voltage divider, 1000 volts at the 1 KV DC socket will also cause 50 μA to flow through the meter.

Section S1 of the Range switch connects the + socket to any one of the six lower resistance taps on the VDC voltage divider. Therefore by changing the position of the Range switch, the operator can place the proper resistance in series with the + socket and the meter to limit the meter current correctly for each voltage range.

DC Calibrate (DC CAL) control R32 is adjusted to compensate for any accumulative tolerances in the meter circuit. Therefore the total resistance in series with the inputs and the meter can be varied to obtain the proper meter indication.

Thermistor RT1 compensates for meter resistance change caused by an ambient temperature change. Since RT1 has a negative temperature coefficient and the meter has a positive temperature coefficient, any ambient temperature change that would cause the meter resistance to increase would cause the resistance of RT1 to decrease. Therefore the total resistance in series with the inputs would remain essentially the same.

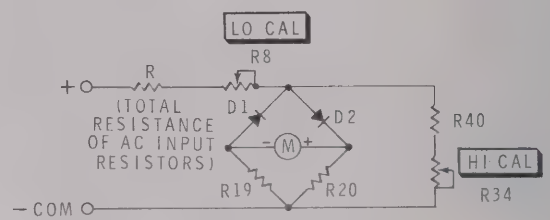


Figure 10

VAC MEASURING CIRCUIT

The simplified ac measuring circuit of your Meter is shown in Figure 10.

The VAC ranges on your Meter use a voltage divider (R1, R2, R3, R4, R5, R6, and R7) that is similar to the one used on the VDC ranges. The 5 KV AC and the 1 KV AC sockets are permanently connected to the high resistance end of the

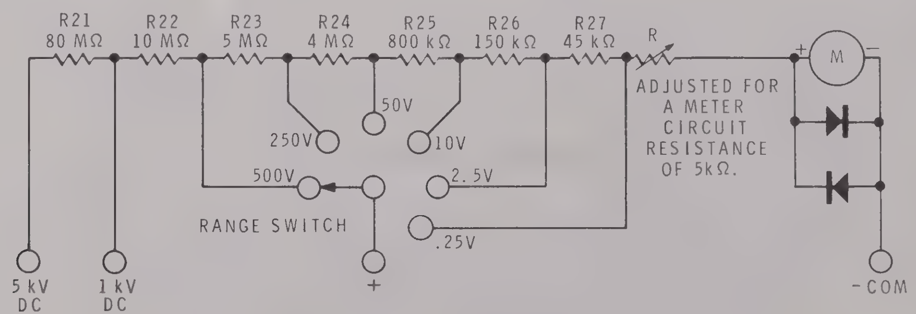


Figure 9

divider. Switch S1 connects the + socket to any one of the five lower resistance taps on the VAC voltage divider to limit the current properly for any one of the VAC ranges.

Rectifiers D1 and D2 convert the alternating current to a direct current that is proportional to the voltage being measured. These rectifiers are classified as "instrument rectifiers" because of their low forward conduction voltage drop, and low reverse leakage current.

When the positive portion of the input voltage is applied, D2 becomes forward biased and allows current to flow through R20 as well as R19 and the meter; then through D2, LO CAL, and R. When the negative portion of the input voltage is applied, D1 becomes forward biased and allows current to flow through R, LO CAL, D1, and R19 as well as the meter and R20. Notice that with either polarity, the current flow through the meter remained in the same direction. Therefore, errors that would have resulted because of unsymmetrical negative waveforms are minimized.

Low Calibrate (LO CAL) control R8 and High Calibrate (HI CAL) control R34 are adjusted to compensate for the accumulative tolerances of the resistors in the ac voltage measuring circuit. When the Range switch is in the 2.5 VAC position, only a small portion of the voltage divider is connected in series with the input voltage. Therefore any change in the setting of R8 will greatly change the total resistance in the circuit, which will change the calibration. Conversely when the Range switch is in the 500 VAC position, a large resistance is placed in series with the input voltage. Since the resistance of R8 is then small when compared to the total resistance of the voltage divider, varying the setting of this control has little effect on the total resistance.

High Calibrate (HI CAL) control R34 is in parallel with the bridge circuit of D1, D2, R19, R20, and the meter. Therefore the adjustment of this control determines how the current is divided between the two parallel circuits and, hence, how much current flows through the bridge circuit and the meter. This makes it possible to adjust the meter to indicate high ac voltages accurately.

OUTPUT CIRCUIT

The Output socket is used for ac measurements. However, a .22 μF capacitor is in series with the Output socket to block the dc component of any waveform. The impedance of this "blocking" capacitor will affect the reading of ac voltages to some extent, especially on the lower voltage ranges and at lower frequencies. On the higher voltage ranges, or at higher frequencies, this effect becomes negligible. A large external capacitor can be used to help measure low voltages at low frequencies, as described in the "Operation" section under the measuring of pure ac.

CURRENT-MEASURING CIRCUIT

The primary function of the current-measuring circuit is to provide some means to shunt the majority of the current being measured around the meter coil. This is necessary because the coil can handle only small amounts of current.

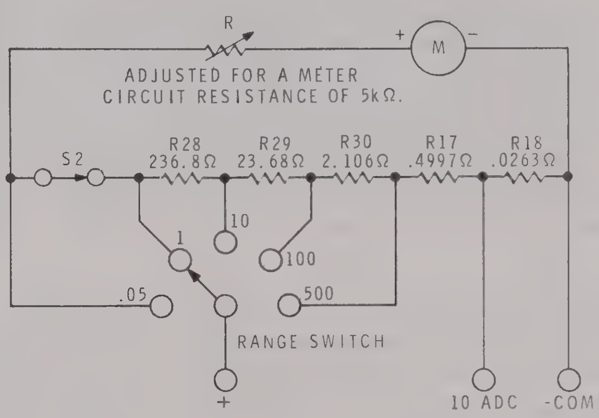


Figure 11

Figure 11 shows the simplified circuit for the 1 mA range of your Meter. Consider the entire circuit as two parallel resistors: one consisting of the meter movement and the other one consisting of resistors R18, R17, R28, R29, and R30, which are switched into the circuit by section S2 of the Range switch. The meter circuit contains a total resistance of 5 kΩ, whereas the five shunt resistors add to a total of only 263.1 Ω's. Since the shunt is approximately 1/19 that of the meter resistance, 19 times as much current will flow through the shunts as will flow through the meter. When sufficient current is being measured to pass 50 μA through the meter coil (the amount required for full-scale deflection), 950 μA will pass through the shunt resistors for a total of 1000 μA (1 mA).

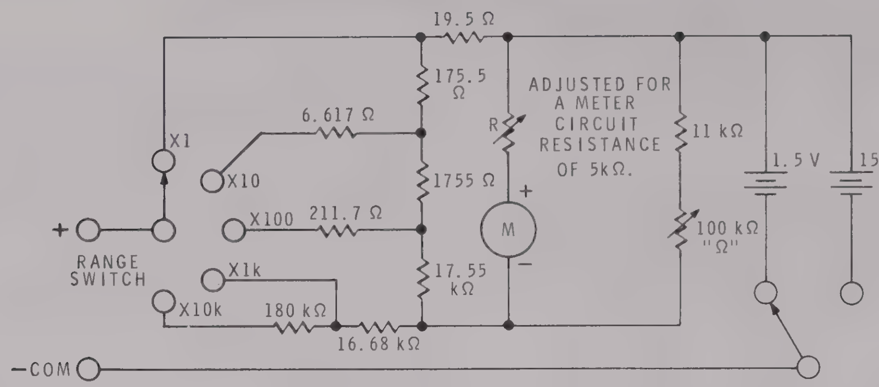


Figure 12

The 10 mA, 100 mA, 500 mA, and 10 A ranges make use of the same circuit. The Range switch, however, becomes an active part of the circuit and the entire system becomes a special circuit called an Ayrton shunt. In this system all of the shunt resistors are permanently connected in a series circuit. This eliminates the possibility of the switch contact resistance affecting the accuracy of the shunt resistance network. When switching from a lower to a higher range, a portion of the lower range shunt is connected in series with the meter circuit. This results in a gradual increase in the full-scale voltage drop across the shunt to compensate for the slight reduction in meter sensitivity.

To avoid an overload to the switch, the high current range on the Meter is brought to a separate socket. When high current measurements are made, the red test lead must be plugged into the 10 ADC socket and the Range switch must be set on the 10 A position.

RESISTANCE-MEASURING CIRCUIT

The Meter uses a potentiometer-type ohmmeter circuit for resistance measurements. In this type of circuit, the external or unknown resistance being measured is connected in series with a battery and an internal standard resistor. The meter then acts as a voltmeter to measure the amount of voltage dropped across the standard resistor.

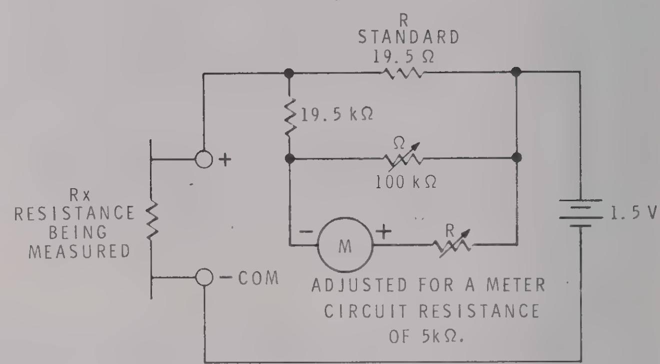


Figure 13

Figure 12 shows the circuit connection of the Meter for resistance measurements. For ease of explanation this circuit can be simplified as shown in Figure 13 for the RX1 range.

Let Rx represent the unknown value of the resistance being measured. If Rx contained an infinite value of resistance (open), then no current could flow through it or the meter. If Rx contained a zero value of resistance (shorted), then maximum current could flow through it and the full battery voltage would be placed across the meter. If Rx contained some value of resistance between infinite and zero, then some proportional amount of current would flow through it and the Meter would indicate between infinite and zero ohms.

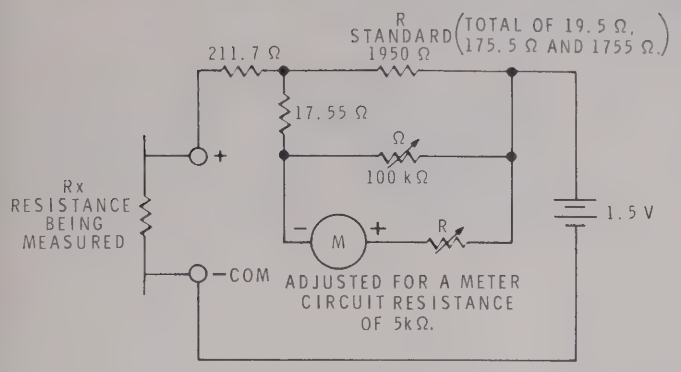


Figure 14

Figure 14 shows the simplified circuit for the X100 range. On this higher range, R standard is 1950 Ω, or 100 times its previous value. The 211.7 Ω resistor is added to compensate for the increased loading effect of the meter circuit, thereby maintaining the mid-scale value at exactly 1950 Ω. This allows the use of the same scale when reading the meter.

This same analysis applies to the Rx10, Rx1k, and Rx10k ranges. However, on the Rx10k range, the 1.5-volt battery is too small to supply the required current. This is compensated for by switching in the 15-volt battery.

METER PROTECTION CIRCUIT

The meter is protected by two diodes connected in parallel with the meter movement (see Figure 9). One of these diodes is connected with the cathode at the positive meter terminal while the other diode is connected with the cathode at the negative meter terminal. Under normal conditions these diodes have little, if any, effect because the voltage across the meter and the diodes is too small to allow the diodes to conduct. If the meter is subjected to an overload, one of the diodes will conduct and bypass the excessive current around the meter. However, if excessive voltage is applied, the pointer may be bent as it hits against the stop. CAUTION: Avoid applying any voltage to the Meter when the Range switch is set in any ohms position.

POLARITY REVERSAL CIRCUIT

The +/− switch in effect, can reverse the Meter's test leads. This switch can be used on the VDC and mA ranges to eliminate the necessity of changing the test lead connections when alternately measuring positive and negative dc voltages or when measuring dc currents that change direction. The two circuits shown in Figure 15 illustrate how these connections are reversed.

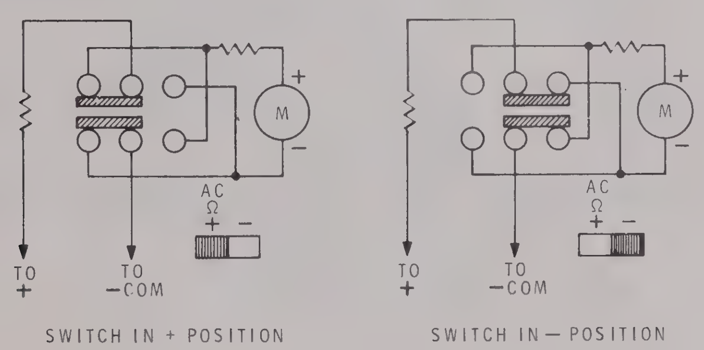
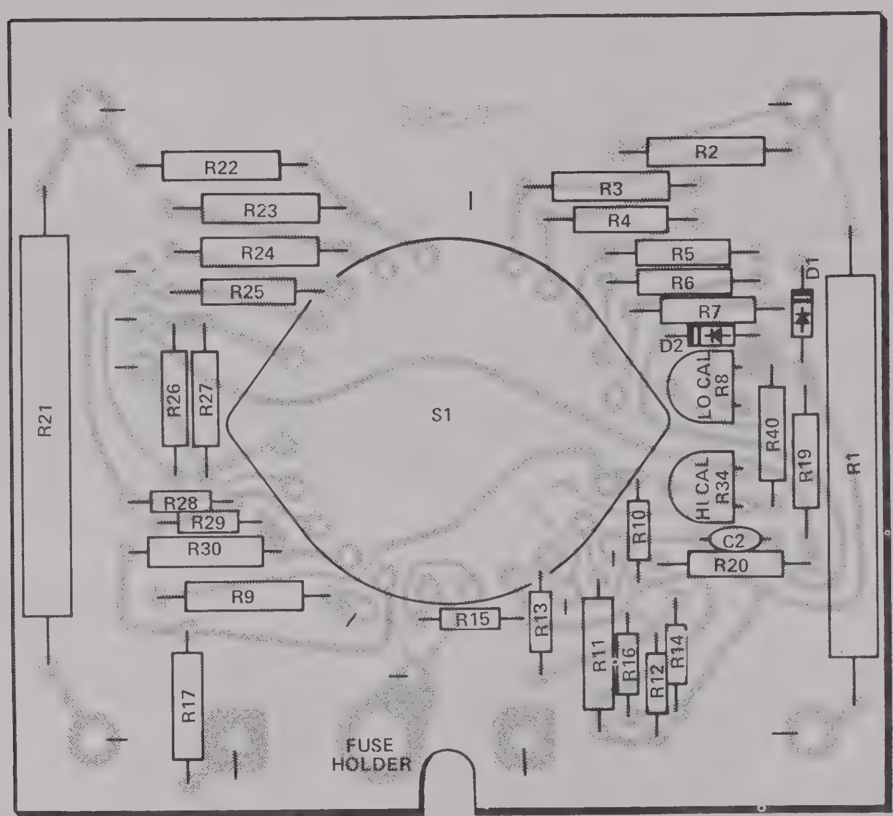


Figure 15

CIRCUIT BOARD X-RAY VIEWS

NOTE: To determine the value (20 kΩ, .02 μF, etc.) of one of these parts, you may proceed in either of the following ways.

1. Refer to the place where the part is installed in the Step-by-Step instructions.
2. Note the identification number of the part (R-number, C-number, etc.). Then locate the same identification number, next to the part on the Schematic. The value, or "description" of the part will be near this number.

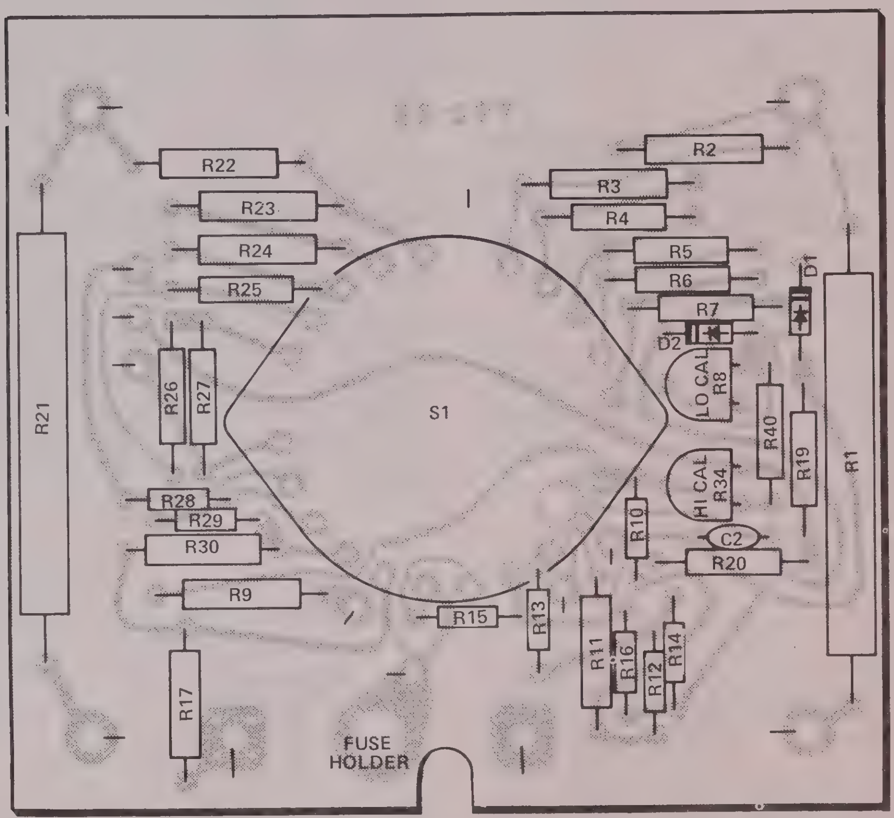


REAR CIRCUIT BOARD
(Shown from foil side)

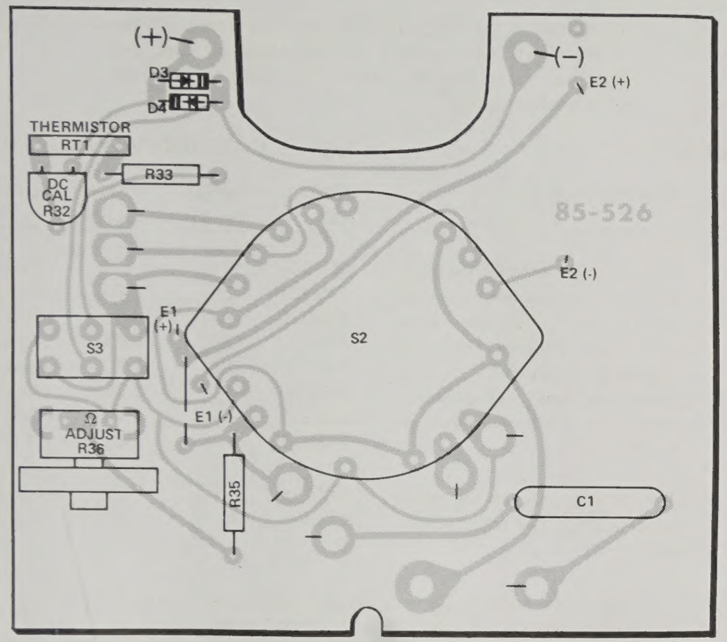
CIRCUIT BOARD X-RAY VIEWS

NOTE: To determine the value (20 kΩ, .02 μF, etc.) of one of these parts, you may proceed in either of the following ways.

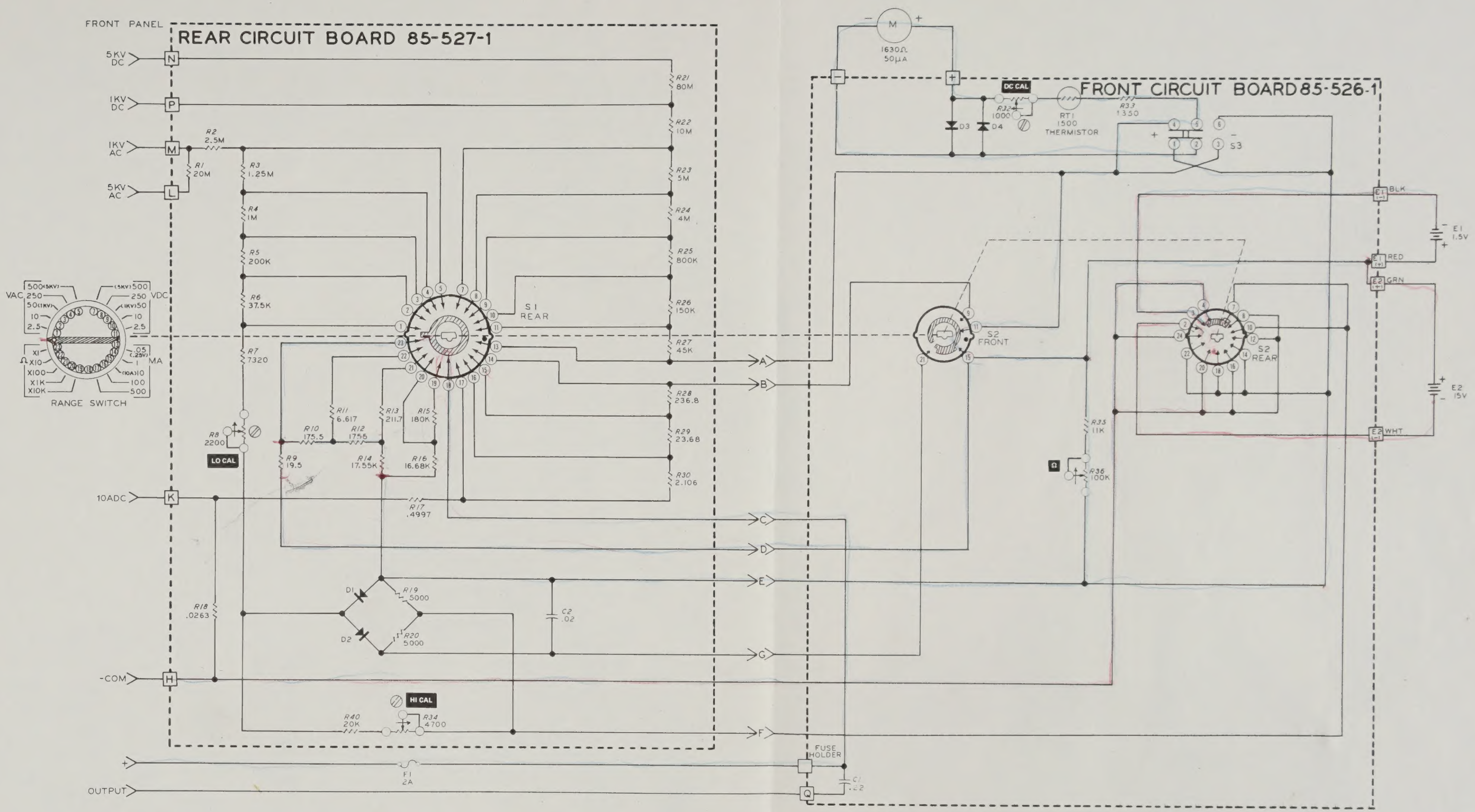
1. Refer to the place where the part is installed in the Step-by-Step instructions.
2. Note the identification number of the part (R-number, C-number, etc.). Then locate the same identification number, next to the part on the Schematic. The value, or "description" of the part will be near this number.



REAR CIRCUIT BOARD
(Shown from foil side)



FRONT CIRCUIT BOARD
(Shown from foil side)



NOTES:

1. RESISTOR VALUES ARE IN OHMS (K=1,000, M=1,000,000).
2. CAPACITOR VALUES ARE IN μF.
3. →>— THIS SYMBOL INDICATES A CONNECTION BETWEEN CIRCUIT BOARDS.
4. >— THIS SYMBOL INDICATES A SOCKET CONNECTOR ON THE FRONT PANEL.
5. □ LETTERS OR SYMBOLS IN A BOX INDICATE LOCATIONS ON THE CIRCUIT BOARDS.
6. ⊘ THIS SYMBOL INDICATES A SCREWDRIVER ADJUSTMENT.
7. → THIS SYMBOL INDICATES CLOCKWISE ROTATION OF CONTROLS OR ADJUSTMENTS AS VIEWED FROM THE KNOB END OF THE SHAFT.
8. REFER TO THE CIRCUIT BOARD X-RAY VIEWS FOR THE PHYSICAL LOCATION OF PARTS.

SCHEMATIC OF THE HEATHKIT®

VOLT-OHM-MILLIAMMETER

MODEL IM-105

METER CASE PARTS REPLACEMENT LIST

In addition to the complete meter and case assembly listed in the "Parts List" section, the following packages and individual parts for the meter case are available for replacement purposes.

METER CASE PACKAGES

PART No.	PRICE Each	DESCRIPTION
407-162	24.95	This package includes the case, meter mechanism, meter window, and meter scale plate only. This package does not include the rear panel, faceplate, detent mechanisms, range switch knob, dust shield, thumbnut, or handle.
409-10	2.55	This package includes the meter window (with zero adjust screw) only.

METER CASE INDIVIDUAL PARTS

PART No.	PARTS Per Kit	PRICE Each	DESCRIPTION
258-144	2	.30	Range detent spring
266-221	2	.20	Range detent roller
462-336	1	1.65	Range switch knob
250-89	2	.05	Meter window screw
211-53	1	.75	Handle
205-805	1	2.25	Faceplate
203-817	1	2.10	Rear panel
252-147	1	.45	Thumbscrew (with hex-tool)
453-219	1	.60	Range switch shaft
462-335	1	.85	Thumbwheel

The above prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Add 10% (minimum 25 cents) to the price when ordering from a Heathkit Electronics Center to cover local sales tax, postage, and handling. Outside the U.S.A. parts and service are available from your local Heathkit source and will reflect additional transportation, taxes, duties and rates of exchange.

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